POWER

Vol. 43 NEW YORK, MAY 2, 1916 No. 18

Purposeful Anecdotes

Fruit Worth Picking Is Worth Climbing For

HESITATING, and with some embarrassment, he entered the office of the manager. Fingering his hat in a nervous way, he said: "I have come to apply for the position of chief. My twenty years' experience in different positions, my faithfulness and loyalty, the results I have had in handling men, entitle me to consideration."

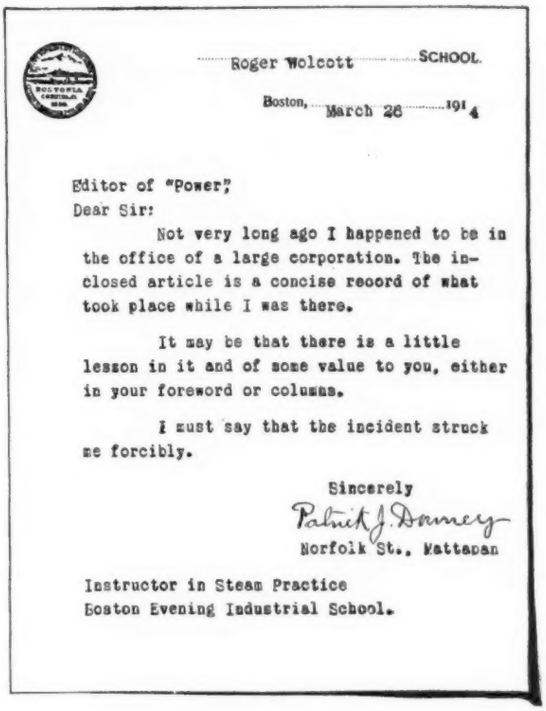
"Good recommendations," replied the manager in a kindly tone, as if impressed with the appearance of the applicant, "and what else might you say?"

Shifting his feet uneasily and unbuttoning his coat, the stranger took some papers from his pocket and laid them on the desk.

"Read these," he suggested.

The big man's eyes took a thoughtful look out into the plant, as if remembering previous applicants for the position. "This position will pay $2200 a year. I must have a man worth that. Before I look at your papers I shall satisfy myself that it is worth my time."

Vigorously swinging his chair, he reached into a filing cabinet and drew out a slip. "Here," placing the paper in front of the other, "is an analysis of our feed water. What is your treatment?"



Roger Wolcott SCHOOL.

Boston, March 26 1914

Editor of "Power",
Dear Sir:

Not very long ago I happened to be in the office of a large corporation. The inclosed article is a concise record of what took place while I was there.

It may be that there is a little lesson in it and of some value to you, either in your foreword or columns.

I must say that the incident struck me forcibly.

Sincerely
Patrick J. Downey
Norfolk St., Mattapan

Instructor in Steam Practice
Boston Evening Industrial School.

"Why—why, I have always sent out the feed water for analysis and treatment," he stammered. "I am not a chemist."

A disappointed look crept over the manager's face as he returned the slip to its place. "I'll give him another chance," he thought.

Walking over to the other side of the office, he took down some plotted CO_2 charts. "Come over and look at these. Do you think we are getting good results?" The applicant's face now became wrinkled in perplexity. "I must confess ignorance as to the purpose of all these," he said. The manager waved his hand signifying that the interview was at an end. "I am sorry that you have not a better idea of what is required of a chief engineer nowadays," was all he said.

The applicant took his papers and departed. He never could know how sorry the other felt—sorry at the thought of the number of men who would work for a pittance rather than spend a few hours a week in study.

The manager stood gazing out into the plant, and half wearily shaking his head, muttered: "Out of thirty men in this plant, not one is fitted."

Municipal Power Plant Operated by Saskatoon, Canada

By A. G. Christie*

SYNOPSIS—Saskatoon sells electrical energy on a commercial basis. Last year its plant made nearly $40,000, after all charges were paid. The fuel cost is high, but good feed water is available for the eight 500-hp. water-tube boilers. Three two-phase 2300-volt alternators are driven by a 1250-hp. compound engine and by 2000- and 3200-kw. Parsons turbines. The plant also supplies 500-volt direct current for railway service.

Saskatoon, a city of about 25,000 population, located almost in the center of the province of Saskatchewan, owns and operates an electric-light and power plant, a street-railway system with 15 mi. of track, a waterworks and sewage system. The main lines of two of Canada's new transcontinental railways pass through the city and, together with many branch lines, make it an important distributing center. The Quaker Oats Co.'s new mill and other plants form the nucleus of its industrial developments. The new Provincial University of Saskatchewan is located at one side of the city, on the hill above the South Saskatchewan River. The growth of the city has been phenomenal, for in 1902 it had a population of only 130 people. Saskatoon is suffering at present from reaction after a real-estate boom and also from the general depression caused by Canada's participation in the war.

The Saskatoon plant is one of those municipally owned utilities that have been operated with a remarkable degree of economy. Its operating costs and electric power and light rates are worthy of careful study by all interested in public ownership.

The first generating station was located about a mile and a half from the center of the town and commenced operation in 1908. When the new plant was started in 1911 this old station had a capacity of 850 kw. Though it still contains a 500-kw. engine-generator set as a reserve, it is now used only as a pumping station.

When the new plant was built two vertical cross-compound four-valve engines were installed. Later a 2000-kw. turbine was added. Then one of the engine units was moved to the old plant where it had originally been and its place occupied by a second turbine of many times the power. When the next demand for increased capacity arises the remaining engine must be removed to make way for another large turbine. The problem of still further power increases thereafter is rather complicated, for the site is such that the engine and boiler rooms cannot be extended very far in the direction of their length. A wing for boilers, at right angles to the present plant, has been proposed, but such a scheme presents difficulties in handling coal and ashes. This situation has developed through failure to provide for future growth when the station was planned.

The new plant, shown in plan in Fig. 2, is centrally located and is on a high bank, about 130 ft. from the South Saskatchewan River, which at this point is a large stream. The building, Fig. 1, has a structural-steel frame, with brick walls and a ferro-concrete roof. The river is subject to floods; hence valves have been placed on all drains from the plant to the river.

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FIG. 1. SASKATOON STATION BUILT WITH BRICK WALLS IN STEEL FRAME

Coal is received on a spur from the adjacent Canadian Northern Ry. tracks. Lethbridge black lignite of about 10,000 B.t.u. per lb. is now being burned. This coal costs $4.50 per ton of 2000 lb. at the plant. Before contracting for coal tests were made on the boilers, and the fuel selected developed the greatest amount of electric power

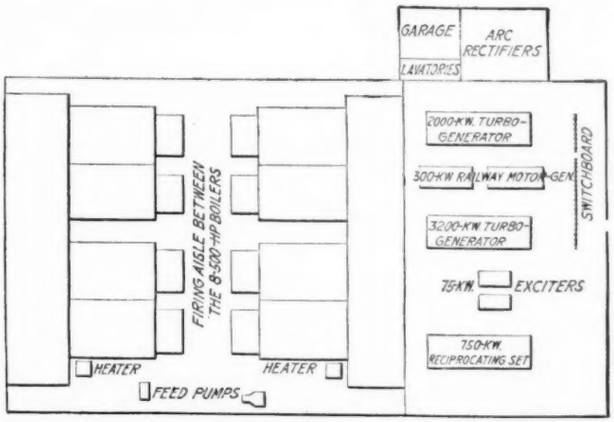


FIG. 2. LAYOUT OF APPARATUS IN SASKATOON MUNICIPAL POWER PLANT

for 1c. Long hauls and consequent high freight rates prevented the use of some good coals, while others were not suited to the furnace and grate conditions. This was particularly true of the low-volatile semibituminous coals from some localities. This coal does not ignite readily, and much of it was carried into the ashpit without being fully burned.

The coal as received on the cars is weighed on a 100-ton track scale, these weights being taken to govern payments. It is then dumped into a steel hopper and passed through a Jeffrey roll crusher with a capacity of crushing 50 tons per hr. from lump size to ¾-in. cube. The crusher feeds into a bucket conveyor, which elevates the coal into four steel bunkers of 500 tons' capacity suspended above the boiler firing aisle.

The same conveyor receives the ashes from the sloping-bottom ashpits and delivers them into either of two ash hoppers with a total capacity of 40 tons. From the hoppers they are run by chutes into cars.

SASKATOON PLANT COSTS FOR YEAR 1914

	Total Cost	Cost per Kw. Hr. Transmitted, Cents.
Fuel	$121,296.68	1.367
Wages	28,972.22	0.326
Water	2,605.71	0.029
Oil and waste	1,110.18	0.013
Miscellaneous supplies and expense	2,840.55	0.032
Maintenance of engines and boilers	11,541.90	0.130
Maintenance of distribution system and arc lights	17,595.59	0.199
Salaries, office expense and bad debts	19,424.56	0.219
Interest on debentures	45,690.22	0.515
Sinking fund	20,983.77	0.236
Depreciation	29,967.76	0.337
Grand total	$302,029.14	3.403

The coal passes from the bins into Avery automatic weighing scales of 200 lb. capacity. A scale for each boiler supplies exact daily records of all coal burned.

A fuel laboratory has been equipped at the plant where proximate analyses of the coal may be made and its heat value determined by a Wright calorimeter.

Eight 500-hp. boilers are installed in rows of two batteries of two boilers on each side of the firing aisle. The safety valves are set at 165 lb. All the boilers are provided with standard superheaters, which can superheat the steam 150 deg. F. Chain grate stokers have been installed and may be driven either by a steam engine or by a 7½-hp. variable-speed 125-volt direct-current motor. The general arrangement of the boiler room is shown in Fig. 3.

A CO_2 recorder is placed in the boiler room to check the performance of the furnace. Draft gages are installed to indicate the suction over the grates.

The flue gases pass out into a smoke flue placed directly behind the boilers, and then pass through economizers. Provision is made, by bypassing the economizer, to send the gases direct to the induced-draft fans. One economizer consisting of 360 tubes in 40 sections is installed for each battery of boilers. The scrapers are engine-driven.

Each row of four boilers is provided with its own induced-draft equipment, consisting of duplicate sets of multivane fans. In each set one fan is engine-driven, while the other is operated by a 30-hp. induction motor. Which set is run depends on the demand for exhaust steam. All the induced-draft equipment and flues are carried on steel framing above the boilers. Hence the stack is very short and projects only about 12 ft. above the roof.

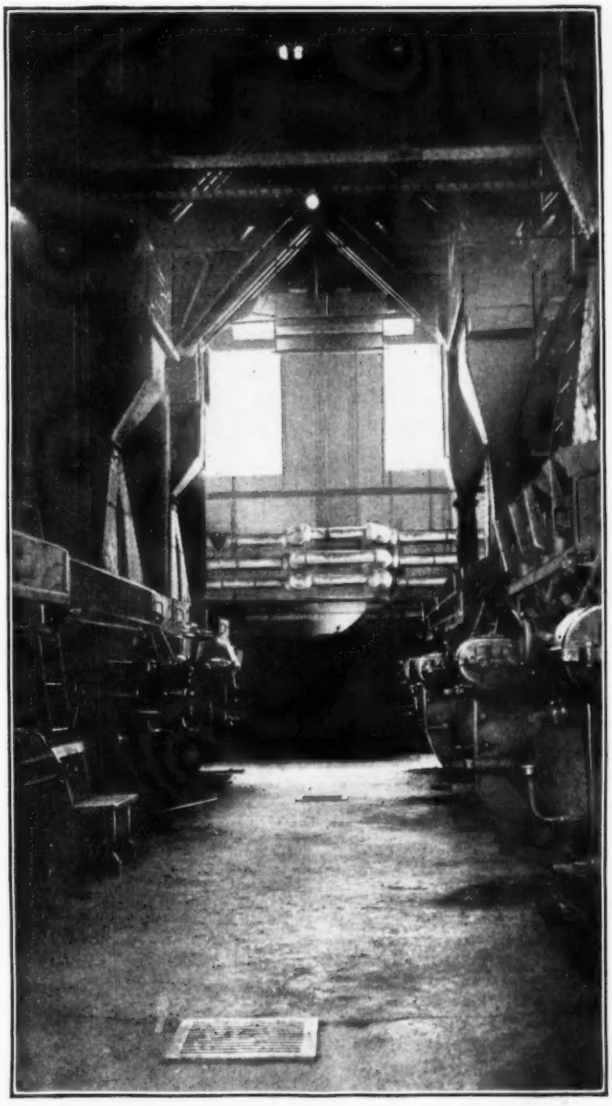


FIG. 3. FIRING AISLE IN BOILER ROOM

The feed water may be heated in either of two heaters. It can be pumped to the boilers by either of two vertical pumps of 7682 Imp. gal. per hr. capacity each or by a duplex pump capable of handling 8000 Imp. gal. per hr. The vertical pumps are provided with sheet-metal valves on the water end. An injector is in place for emergency use. The feed-water mains to the boilers are 3½ in. in diameter and also have connections to the economizers. A motor-driven centrifugal turbine pump for boiler feed has been ordered, but its delivery is held up by the war.

A flow meter has been installed on the feed lines to record the water supplied to the boilers. Condensed steam is used for boiler feed. The makeup water is taken from the city mains and contains little alkali and small amounts of scale-forming materials.

The engine room, Fig. 4, contains one vertical cross-compound four-valve engine of 1250-hp. at 120 r.p.m. A 750-kw. alternating-current generator is placed between the two cylinders. This unit is now used only for peak loads.

There are two Parsons turbines—one of 2000 kw. at 1800 r.p.m., installed in 1912, while the second, of 3200 kw. capacity at 3600 r.p.m., was put in early in 1914. The 3200-kw. machine is of the double-flow type.

The 2000-kw. turbine exhausts into a surface condenser. A Mullen vacuum pump delivers the condensate to a Lea recorder. In this way a continuous check is kept on the steam consumption of the turbine. The recorder is also a reliable indicator of split condenser tubes.

The 3200-kw. unit is supplied with a surface condenser, with tube banks arranged in the form of a W. The vacuum is maintained by a hydrulic air pump driven by a 25-hp. induction motor. A condensate pump delivers the condensate to the Lea recorder.

All condensed steam before going to the heaters is passed through a Ross filter to remove any oil or solid material. The condenser circulating water is furnished by two centrifugal pumps, placed in the well in a pump house on the river bank, directly across the street from the power house. One of these has a capacity of 4200 Imp. gal. per min., while the other can handle 3000 Imp. gal. per min. against a 70-ft. head. Both are of the double-inlet type, driven by induction motors. Two motor-driven pumps of 1000 Imp. gal. per min. capacity, operated in series, are placed in the well as reserves.

The discharge from the pumps is conveyed to the condensers through 18-in. cast-iron pipes placed in a well-built tunnel connecting the pump house and power plant. The outflowing water from the condensers leaves through a similar pipe laid in the ground outside. A connection with the city water mains is used as a circulating water standby.

The steam-operating conditions in the plant are 150-lb. steam pressure, 100 deg. F. of superheat at the throttle and 28½ in. of vacuum referred to a 30-in. barometer.

The main generators are 60 cycle two-phase 2300-volt alternators. It seems that the original units installed in the old station were two-phase alternators. A great mistake was made in not changing over to three-phase when the new station was built. It would have been comparatively simple to make the change at that time.

Two 300-kw. 720 r.p.m. motor-generator sets, consisting of a synchronous motor and a 500-volt direct-current generator, are installed in the engine room between the two turbines and supply power for the street railways.

PRINCIPAL EQUIPMENT OF SASKATOON'S MUNICIPAL POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
8	Boilers	Water-tube	500-hp	Steam generators	165 lb. pressure, 150 deg. superheat	Babcock & Wilcox, Ltd.
8	Stokers	Chain grate		Boiler furnace	Engine or motor-driven	Babcock & Wilcox, Ltd.
4	Economizers	Tubular	360 tubes	Heating boiler-feed water	Heated by flue gases from boilers	Green Fuel Economizer Co.
4	Fans	Induced-draft		Producing furnace draft	Two engine-driven, two motor-driven	B. F. Sturtevant Co.
2	Stacks	Steel		Serving boilers	Induced draft	B. F. Sturtevant Co.
1	Track scale		100 tons	Weighs coal in cars		Fairbanks Morse Co.
1	Crusher	Single-roll	50 tons per hr.	With lump coal		Jeffrey Mfg. Co.
1	Conveyor	Bucket	50 tons per hr.	Handles coal and ash		Babcock & Wilcox, Ltd.
4	Bunkers	Suspended, steel	500 tons	Coal storage		Babcock & Wilcox, Ltd.
2	Heaters	Open		Heating boiler feed-water	Receives exhaust from all auxiliaries	Harrison Safety Boiler Works
2	Pumps	Vertical	12,000 I. G. P. H.	Boiler-feed	Sheet steel valves on water end	G. & J. Weir
1	Pump	Duplex, outside plunger	8,000 I. G. P. H.	Boiler-feed		John McDougal Co.
1	Engine	Vertical cross-compound	1250-hp	Driving generator	Condensing, 120 r.p.m.	Robb Engine Works
1	Generator	Alternating-current	750-hp	Light and power peaks	2300-volt, two-phase, 60-cycle, 120 r.p.m.	Canadian General Electric Co.
1	Condenser	Surface		With compound engine	Has Fairbanks vacuum pump	C. H. Wheeler Mfg. Co.
1	Turbine	Horizontal-reaction	2000-kw.	Driving generator	Condensing, 1800 r.p.m.	Allis-Chalmers Co.
1	Generator	Alternating-current	2000-kw.	Light and power service	2300-volt, two-phase, 60-cycle, 1800 r.p.m.	Allis-Chalmers Co.
1	Condenser	Surface		With 2000-kw. turbine	Has Mullen air-pump	C. H. Wheeler Mfg. Co.
1	Turbine	Horizontal reaction, double-flow	3200-kw.	Driving generator	Condensing, 3600 r.p.m.	Westinghouse Machine Co.
1	Generator	Alternating-current	3200-kw.	Light and power service	2300-volt, two-phase, 60-cycle, 3600 r.p.m.	Westinghouse Machine Co.
1	Condensor	Surface		With 3200-kw. turbine	Jas Leblanc air-pump	Westinghouse Machine Co.
2	Turbines	Horizontal-impulse	75-kw.	Driving exciter	Noncondensing, 2400 r.p.m.	Allis-Chalmers Co.
2	Generators	Direct-current	75-kw.	Excite main units	125-volt, 2400 r.p.m.	Allis Chalmers Co.
2	Motors	Synchronous alternating-current	300-kw.	Driving generator	2300-volt, two-phase, 60-cycle, 720 r.p.m.	Canadian Westinghouse Co.
2	Generators	Direct-current	300-kw.	Street-railway service	500-volt, 720 r.p.m.	Canadian Westinghouse Co.
1	Crane	Hand, traveling		In engine room		

Excitation is furnished by two 75-kw. 125-volt generators, driven at 2400 r.p.m. by impulse turbines, which exhaust into the feed-water heater. A motor-generator exciter set has been ordered, but its delivery is held up by the war.

The switchboard, which is on the engine-room floor, is made up of several types of panels and instruments for the 2300-volt alternating-current circuits, the 500-volt railway service and the 125-volt exciter-busbars. This equipment will soon be superseded by a complete new board, already ordered, which will be placed in a new annex behind and above the location of the present board.

The rectifiers and regulators for the street are lighting are housed in a small addition at the end of the engine room. A transformer station has been installed at the pumping plant, where the voltage is raised for transmission to the new Dominion Government elevator, west of the city. Three single-phase 2300- to 11,000-volt 60-cycle 400-kw. transformers have been installed. The pumping station and filter plant are now supplied throughout with motor-driven centrifugal pumps. The old steam pumps are held in reserve.

The total cost of the power plant, including buildings and machinery was about $570,000. The total expenditure for the complete lighting and power system to Dec. 31, 1914, amounted to about $1,300,000, all of which was raised by city debentures.

Of the 18,220 tons of coal burned during 1914 one-third came from Ohio, one-third was Rocky Mountain

semibituminous and the remainder black lignite from the Lethbridge district. The average cost was $6.66 per ton. The coal consumption per kilowatt-hour transmitted from the plant was 4.11 lb., giving an average fuel cost per kilowatt-hour of 1.367c.

The total energy generated in 1914 was 9,716,142 kw.-hr. Of this quantity 8,873,642 kw.-hr. was transmitted, and the rest, 843,500 kw.-hr., was consumed in the plant itself. The service meters registered 7,966,920 kw.-hr. The distribution loss was therefore 906,722 kw.-hr., or 11.37 per cent. of the power accounted for by the service meters.

The city's electric light and power operating account for 1914 has been regrouped into the figures given in the accompanying table. Results obtained during the first five months indicate that the fuel cost for 1915 will be reduced from the 1914 figures, 1.367c., to about 1c. per kw.-hr. For the whole year the average costs per kilowatt-hour of energy generated, transmitted and metered were 3.11, 3.403, and 3.795c. respectively. The corresponding revenues were 3.51, 3.84 and 4.28c. The Electric Power Department made a profit for the year of $38,598.94. This was transferred to the general revenue account.

There is no service charge for electrical demand, but the city requires deposits on all meters installed. There is a minimum monthly charge of $1 for lighting and $2 for power service. The lighting accounts are subject to a 10-per cent. discount if paid in 10 days from the date of billing. All charges for service are made monthly. The lighting rates are 8c. per kw.-hr. for the first 100 kw.-hr., 7c. for the next 50 and 6c. for all over 150 kw.-hr. per month.

The power rates are 5.4c. for the first 750 kw.hr., 3.25c. for the next 2250, 2.34c. for the next 1000, and 2c. for all energy over 4000 kw.-hr. per month. Domestic power is sold at 4c. per kw.-hr. One customer with a 24-hr. demand consumed 1,160,920 kw.-hr. in 1914, and the City Council granted him a special rate of 1¼c. per kw.-hr. The Dominion Government elevator has its current metered on the low-tension side of the high-voltage transformers and is given a 2c. rate. These low rates were quoted to build up the load and to encourage industrial development in Saskatoon.

The Electric Power Department is in charge of E. Hanson, who was chosen electrical engineer by the City Council in 1913. The recent improvements in the plant have been made under his direction. Credit is due to him, to the assistant electrical engineer, J. R. Cowley, and to the plant's chief engineer, C. A. Cutting, for much of the information in this article.

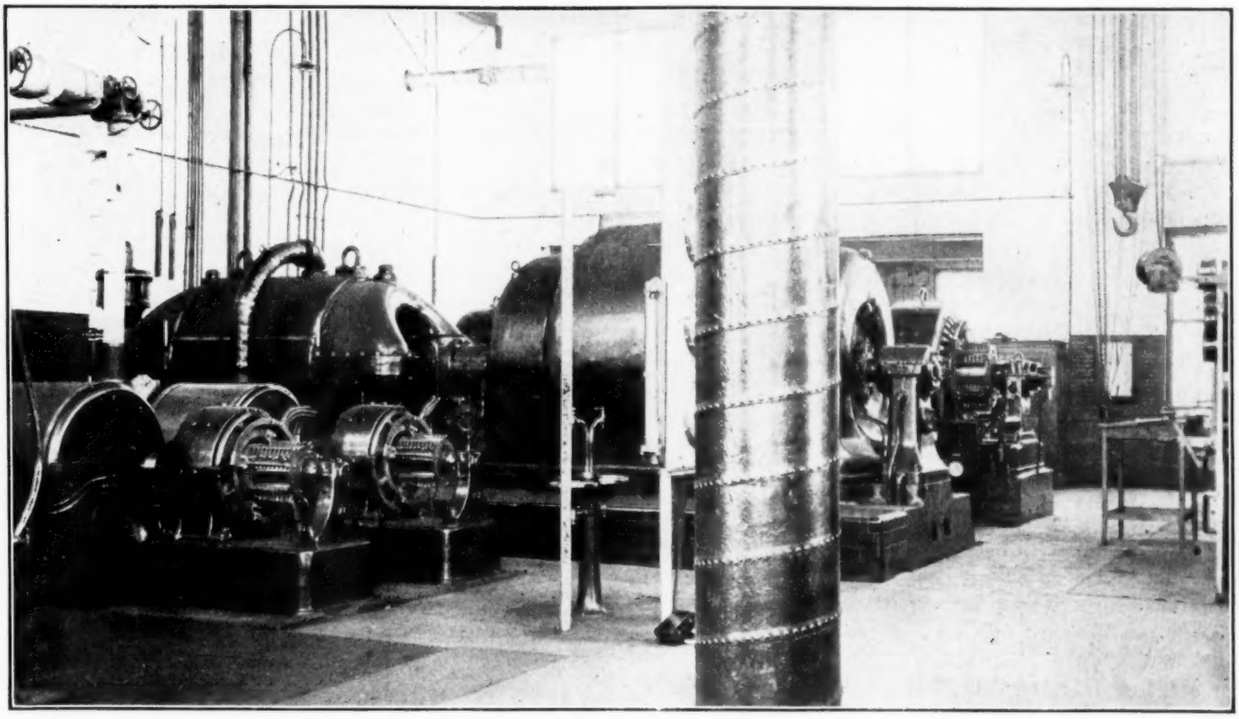


FIG. 4. TURBINE AND ENGINE ROOM, WITH TURBINE-DRIVEN EXCITERS AT LEFT

Measuring Circles and Spheres

The measurements of circles and spheres may be memorized readily by associating them with squares and cubes corresponding to the diameter of the circle (to be termed D in each figure). For example:

The distance around a square figure is equal to one side D × 4, while the distance around (circumference of) a circle is equal to D × 3.1416 (instead of 4).

The area of the square = D^2, or $(\frac{1}{2}D)^2 \times 4$, while the area of the corresponding circle = $D^2 \times 0.7854$, or $(\frac{1}{2}D)^2 \times 3.1416$ (instead of 4 as in the other case).

A cubical figure has an external area equal to the area of one side multiplied by 6 (having 6 sides), while a sphere's surface equals the area of its great circle times 4.

The volume of a cube = D^3 (distance in three directions multiplied together) and that of a sphere = $D^3 \times 0.5236$, or $D^3 \frac{3.1416}{6}$

SQUARE	CIRCLE
Circumference = Diameter × 4	Circumference = Diameter × 3.1416
Area = D^2 or $(\frac{1}{2}D)^2 \times 4$	Area = $D^2 \times 0.7854$, or $(\frac{1}{2}D)^2 \times 3.1416$
CUBE	**SPHERE**
Area = Area one side × 6	Area = Area of circle × 4
Volume = D^3	Volume = $D^3 \times 0.5236$, or $D^3 \times \frac{3.1416}{6}$

Diesel-Engine Operation at Palo Alto Municipal Plant

SYNOPSIS—Abstract from the report of the city engineer giving the results of the year's operation. The Diesel unit has shown marked economy over the steam plant, and is in almost continuous operation. About the only trouble experienced has been an occasional sticking of the pistons, due probably to imperfect combustion when operating on light loads.

The City of Palo Alto, Calif., a little over a year ago installed a 450-hp. Koerting Diesel engine in its municipal power plant.[1] This station furnishes electric light, heat and power throughout the community, totaling about 1,500 active commercial connections; it also supplies service for the municipal water-works and for motor operation at the garbage incinerator. The yearly output approximates 1,140,000 kw.-hr., with an average peak load of 360 kw.; the average load factor is about 40 per cent. Prior to the installation of the Diesel engine, the station equipment consisted of four noncondensing steam engines of 800 hp., total, operating four 60-cycle two-phase alternating-current generators, with an aggregate capacity of 485 kw.

The Diesel unit, installed to replace one steam engine and increase the capacity of the plant, was placed in operation in December, 1914, to carry the main load under 24 hr. service, and has since been operated almost continuously. During this time the fuel-oil cost has been reduced from $12,000 to $6,000 a year, while tests show that the actual fuel cost of operating the unit is about two mills per kilowatt-hour.

With this indication of economy in operation, the accompanying data, based upon a recent report of J. F. Byxbee, Jr., city engineer, covering the first year's service, sets forth various important features of the performance of the Diesel engine. The efficiency attained during the period shows the possibilities of such a prime mover for electric-power installations to render service to communities of this character.

Fuel Used and Economy Obtained

The fuel used, obtained from the Richmond, Calif., section, is the same as burned under the boilers in the steam plant, with composition about as follows: Specific gravity at 15 deg. C., 0.95; Baumé equivalent, 15.9 deg.; water and dirt, trace; sulphur, 0.776 per cent.; heat value, 18,000 B.t.u.

In Diesel engines using the needle type of injection valve it would be difficult to use this fuel successfully, but with the open type of injection valve adopted in the Koerting engine, the oil is handled readily, especially when heated to the point of easy flow. In this injector the oil is pumped under low pressure into a receptacle behind a check valve separating it from the cylinder. At the proper time high-pressure air is admitted to this chamber and blows the oil through the check valve and a nozzle on the end of the injector into the cylinder; here it is immediately ignited by the high temperature of the air compressed in the cylinder.

The fuel-oil tank is jacketed with hot water, also the fuel-oil pipes leading from the tank to the injectors; the water supplied to these jackets is warm water taken from the cylinder jackets.

It is necessary to use a light oil, such as Calol fuel oil of about 24 deg. Baumé when starting the engine cold.

During the acceptance tests made by R. E. Mathot, at Hanover, Germany, with Richmond fuel oil of 17,741 B.t.u. low-heat value, the following results were obtained: At full load, 0.388 lb. (0.0492 gal.) per b.hp.-hr.; at three-quarter load, 0.385 lb. (0.0487 gal.) per b.hp.-hr.; at one-half load, 0.439 lb. (0.0556 gal.) per b.hp.-hr.

In the regular operation of the plant the engine gives from 9 to 12 kw.-hr. per gallon of fuel oil at the switchboard, depending upon the load conditions during the time the measurements are taken. This is equivalent to about 0.52 to 0.45 lb. per b.hp.-hr.

The station economy in kilowatt-hours output per gallon of fuel oil, taken month by month since the installation of the unit, up to August, 1915, is as follows:

Month	Kw.-Hr. per Gal. of Fuel Oil
Before installing Diesel engine	1.75
December	3.39
January	4.21
February	3.55
March	3.78
April	4.08
May	4.60
June	5.58
July	5.49
August	5.10

The reason that the station economy compares rather unfavorably with the Diesel-engine economy is due to the fact that one or more of the boilers is maintained under pressure at all times to hold the steam plant ready to take the load should anything happen to the Diesel unit, and also to have available at any time additional power for a sudden increase in the load or to furnish steam for the steam fire pumps; additionally, the operation of the steam engine for two to four hours over the peak load each evening cuts down the station economy materially.

Lubricating Oil and Cooling Water

The crankshaft and connecting-rod bearings of this engine are lubricated by an oil-circulating system consisting of a pump, reservoir, cooler and strainer. The reservoir is filled with oil that overflows from the cylinder and piston lubrication, and with filtered oils. The camshaft bearings all have reservoirs and ring oilers, and all gears run in oil, so that it is seldom necessary to give these parts any attention. An average of 5 gal. per day of lubricating oils, including that for the air compressor is used, costing about 35c. per gal. The entire cost of lubricating oil required for the station has increased approximately $10 per month since installing the Diesel engine.

About 2,000 gal. of water per hour is used for cooling the engine, this figure varying considerably with the load. Water waste is reduced by using a small cooling tower.

[1] See "Power," Apr. 13, 1915, for complete description of this engine.

The pump for this circulating-water cooling system requires 1.66 kw., or about 1,200 kw.-hr. per month. The station uses approximately 275,000 gal. per month less for operation since the installation of the Diesel engine. At 12c. per 1,000 gal. for the water, and allowing 1c. per kw.-hr. for electric energy used in the circulating-water system, the water cost to the station is about $21 less per month than formerly.

Supplies, Repairs and Cleaning

Up to this time the cost for miscellaneous supplies, such as packing, waste and other minor materials, has been lessened since the installation of the Diesel unit. Such an engine practically eliminates packing, as most of the joints are ground and there are no stuffing-boxes of any considerable size or importance. There are a few copper-asbestos gaskets, but these are small and long-lived, so their cost is insignificant.

Beyond the cleaning of exhaust valves, cylinders and pistons, repairs on the Diesel engine have been quite negligible. Up to the present time the worst trouble appears to be that of keeping the pistons clean enough to operate without sticking in the cylinders. A practice has been adopted of removing and cleaning each piston once every four weeks. While instructions for the engine state that the pistons should be cleaned about once every three months, depending somewhat upon the nature of the fuel oil, the experience has been that the engine would not run for that length of time without cleaning.

As the engine is of the horizontal type, it permits of easy withdrawal of the pistons. Four men can withdraw, clean and replace the four pistons in less than 12 hr. It is the practice to shut down the engine about 8 hr. each week to clean one piston and two exhaust valves, and such other work as may seem necessary. Besides this work the record for repairs, including the month of August, is as follows:

Time	Hours Out of Service	Trouble
Dec. 2	3	Injection valve stuck
Dec. 7, 8, 9	72	Broken gear in lubricating pump
Dec. 11, 12	28	Changing air inlet to air compressor
Dec. 19, 20	24	Piston No. 2 stuck. Taken out and cleaned
Dec. 21	18	High-pressure piston rings of air compressor worn out
Jan. 4	20	Piston No. 4 stuck; engine cleaned
Feb. 24	9	False head of No. 3 piston renewed
Mar. 27	3	Broken valve in low stage of air compressor
May 3	8	Lubricating-oil pipe stopped up
July 18, 19, 20, 21	96	Piston No. 3 stuck; engine cleaned
Aug. 16	3	Valve in high stage of air compressor stuck

No particular trouble has been experienced with the high-pressure air system. The valves, fittings, piping and air compressor seem to be capable of withstanding high pressures. The injection pressure is often maintained at 1,050 lb.per sq.in., although at low loads it is generally reduced to 900 lb. No soot has accumulated in the mufflers or exhaust pipes.

Between Dec. 1, 1914, and Sept. 1, 1915, the Diesel engine has operated 5,980 hr., or 91 per cent. of the total time. Of the period the engine was shut down, 312 hr. was for the regular cleaning periods, and 284 hr. for repairs and extraordinary cleaning, as noted in the foregoing table.

The regulation of the unit under ordinary load conditions has been found very satisfactory—even better than that of the steam engines at the plant. Not the slightest difficulty has been encountered in operating the Diesel-engine generator in parallel with any or all of the other steam-driven generators.

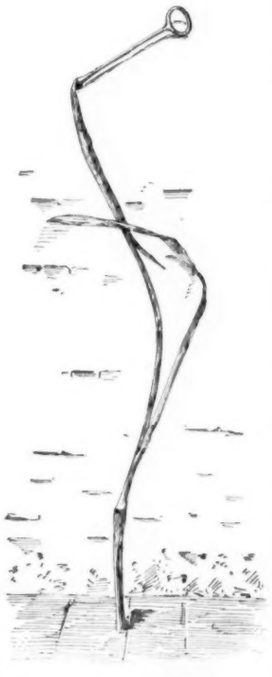
The operating force at the station is the same as before the Diesel engine was installed. The steam engineers apparently had no difficulty in handling this new type of machine, although the Diesel engine requires closer attention than a steam engine.

At this station the Diesel engine is started and the load taken on in about three minutes. Since operating the unit, it has stopped on five different occasions so suddenly as not to give sufficient time to transfer the load to some other machine. In three cases this sudden stoppage was due to the sticking of the pistons, once through the sticking of the injection valve, which let the high-pressure air out of the tanks, and once because of the sticking of a valve in the air compressor. The Diesel engine does not seem to act as well as the steam engine when frequent "shorts" occur on the line, which cause the load to be suddenly released or put on.

It is estimated that the Diesel unit installed at this plant should last twenty years if it is given good attention. The design of this particular type is very liberal and all parts run smoothly. Of course there will be replacement of parts and cylinder liners required, but from the present indications this work will not have to be done often, so the repair expense should not be heavy even after a long period of service.

Explosion of a Firing Tool

Herewith is reproduced a photograph of a firing tool which exploded. It appears that in the Manchester district, and it may be in others, boiler-firing tools are often made in three pieces, the ends being solid and welded to a central length of iron piping. The tool is considerably lighter than if solid throughout and is amply strong when used as a rake or slice. The pipe from which the tool in question was made was of a rather poor quality of iron. It was 1-in. diameter inside and about ⅛ in. thick. The solid handle was about 18 in. long and also the slicer end, so that with 5 ft. of piping the total length was about 8 ft.



EXPLODED FIRING TOOL

It is stated that the explosion was a violent one and occurred during the actual slicing of the fire. Unfortunately the man who was using the tool was badly shaken and somewhat burnt, and as there may be many other hollow firing tools of the same type in use, it is desirable that this extraordinary accident should be made known.

Two or three theories have been put forward as to the cause, but the most feasible seems to be that the tube was burst by steam pressure. We understand that the tool had recently been repaired, and it is possible that when the welding, say of the pointed end, was done a minute hole or crack remained in the tube, and as the tool was prob-

ably put into water after the welding, a partial vacuum would be formed in the tube on cooling, so that water would be drawn in. The small opening which admitted the water would shortly be sealed by rust, so that when the tool was heated during the stoking operation steam would be formed and a dangerous pressure rapidly accumulated. Obviously the drilling of a few holes at the handle end of the tube would have prevented the accident, and it would be well to have all such tubular firing tools so treated.—"Vulcan."

Producer Operation and Testing

By A. A. Potter*

SYNOPSIS—Notes on the selection of fuels for a producer and the conditions and items essential to making a test.

One of the most important factors to be considered in the selection of a gas-producer fuel is its volatile constituents. The fuel that produces tar and lampblack in large quantities will require an elaborate scrubbing system and will increase the operating expenses in connection with the upkeep of engines and pipe lines. For this reason producers burning oil fuel are but little used. The amount of tar-forming gases is small with anthracite coal, greater with lignites and most objectionable with bituminous.

The kind of ash is also of importance. If the ash fuses or fluxes to a clinker, the proportion of steam to air in the blast must be increased to reduce the temperature of the fuel bed. This decrease in temperature reduces the formation of the combustible carbon monoxide (CO) in the producer. If too much steam has to be used, the percentage of hydrogen will decrease the safe compression pressure when the gas is used in an internal-combustion engine.

Clinker formation is also serious because it obstructs the gas passages, requiring increased blast pressure to allow the air to pass through the fuel bed. With the increased resistance through the fuel bed, the blast will scale the walls and cause blow-holes in the fire bed, thus increasing the amount of CO_2 in the gas and reducing the efficiency of the producer. Increasing the draft means also greater cost for driving the fan and a reduction in the capacity of the producer. Greater trouble from clinkering is usually encountered with anthracite than with bituminous coals, unless the latter is rich in sulphur (in the form of iron pyrites). Even conditions during producer operation and careful poking will reduce the difficulties from clinker.

The size of coal has considerable influence on the efficiency and capacity of a gas producer. If the coal is too large, too little surface is offered for gasification and the ratio of carbon monoxide to carbon dioxide in the gas is reduced, resulting in a lower efficiency of the producer. A nut size of bituminous coal is best while the pea-size anthracite gives good results. If the coal is too fine, the resistance through the fuel bed is increased, requiring greater blast pressure, and this reduces the capacity of the producer.

Dry filters, consisting of layers of iron filings and wood shavings, are satisfactory for removing sulphur from producer gas, but the filings must be changed frequently, if the coal contains more than two per cent. sulphur.

*Dean of the engineering division and professor of mechanical engineering at the Kansas State Agricultural College.

The grate area, the rate of gasification and the depth of the fuel bed are affected by the character of the fuel, the lower-grade fuels requiring a larger grate area, slower rates of gasification, and deeper fuel beds. With bituminous coals a rate of gasification of about 8 lb. of coal per square foot of grate surface will give good results. For best operation the blast of the mixture of air and steam should be admitted so that it will come in direct contact with the incandescent fuel bed and be distributed over the whole area of the bed.

A deep fuel bed is essential for the proper reduction of carbon dioxide to carbon monoxide and for the production of uniformity in the calorific value of the gas, with rapid load fluctuations. Irregular charging and variation in the ratio of steam to air in the blast will cause fluctuations in the quality of the gas. A producer bed in the best condition should have a uniform red temperature; bright spots in the bed indicate the presence of blow-holes. In the operation of producers it will be noticed that the blast will tend to produce a more rapid burning of the walls. This, and the occurrence of blow-holes, should be avoided by careful poking.

Data Necessary to Find Producer Efficiency

To ascertain the efficiency of a producer, these data must be obtained—the quantity of fuel used, the amount of gas generated, the calorific value of the fuel and that of the gas. The calorific values of the fuel and of the gas can be easily obtained by constant volume and by constant-pressure calorimeters, respectively, but difficulty is experienced in determining the amount of fuel used and the volume of gas generated.

The difficulty in measuring the quantity of coal arises from the fact that the coal gasified is not the same as the coal fired. Experiments with a bituminous coal producer at the engineering laboratories of the Kansas State Agricultural College show that it takes, during continuous operation, 10 to 20 hr. for each charge of fuel fed to the producer hopper to reach the ashpit. For boiler tests the standard codes specify 24-hr. tests to reduce the error in fuel measurement to a minimum. Since it takes only about half an hour to burn the charge of coal in the boiler furnace, evidently producer tests to be of any value should be several hundred hours long. It has been recommended that the length of a producer test should be such that the total consumption of the fuel should be at least ten times the weight of fuel contained in the producer when in normal operation. This specification for the length of a producer test does not seem to be definite. The duration of a producer test should be at least equal to 25 times the length of time the fuel remains in the bed of the producer. The results of producer tests of 2 to 8 hr. duration have appeared in print from time to time, but they are of little value.

Great difficulty is also experienced in measuring the quantity of gas generated. Wet station meters are bulky and expensive; they have also a tendency to absorb some of the gas. The author has used various forms of pitot tubes with little success. The venturi tube seems to be the best type of meter for measuring large volumes of producer gas, but in using it care must be taken that the tube is clean. Deposits of tar or moisture in the tube will reduce its accuracy.

The correct ratio of steam to air in the blast of a producer has never been determined correctly. Most experimenters do not take into consideration the saturation of the air mixing with the steam. This ratio naturally differs with the load. The power consumed by fans, scrubbers and other auxiliaries should also be determined in a complete test.

Some form of continuous gas calorimeter proves very useful in the testing as well as in the daily operation of gas producers. The gas samples should be taken at a point in the main sufficiently removed from the producer to guarantee proper gas conditions. The ratio of CO to CO_2 in the gas is also of considerable value in indicating the proper working condition of a producer. A ratio of 7 to 10 per cent. CO to 1 per cent. CO_2 indicates good producer operation.

Both proximate and ultimate analyses of the coal are desirable. A careful quantitative analysis of the gas should also be made, as this will prove a check on the fuel measurements.

Two Five Thousand Ton Coal Storage Equipments

By Henry J. Edsall*

The value of an adequate coal storage in connection with a power plant is coming to be appreciated more and more. A reserve storage of this kind is a valuable insurance against the closing down of the plant and also has several other advantages, among which are the possibilities of more advantageous purchasing of coal and the saving in the cost of handling with the aid of a proper equipment for the conditions obtaining.

*Engineer with the Link-Belt Co.

Many engineers do not, however, appreciate that the improvements in mechanical equipments have placed the methods of handling and storing coal far in advance of the older ones, such as the railroad trestle or the lowering of the boiler-room floor and the use of vaults underneath the railroad track or below the ground level. With a mechanical equipment the coal can be placed right where it is most convenient, piled to the most advantageous depth, and the machinery can be arranged to handle from storage as well as into storage if desired. In addition to this, the mechanical equipment is likely to be the cheapest in first cost.

In the two reserve-storage equipments illustrated, 5,000-ton plants have been selected. In one simplicity, low first cost and ease of operation are the prime considerations, but no provision is made for reclaiming the coal. In the other it is assumed that the reserve storage will be called on more continuously, so that it is advisable to be able to take the coal out of storage with the machinery as well as to put it in.

The former equipment, illustrated in Fig. 1, is suitable especially for a small plant where the coal supply is irregular; for instance, on a branch railroad that might get snowbound in winter or where there is no railroad at a plant and the coal has to be hauled some distance and a large enough supply stored in the fall to last through most or all of the winter. A plant of this kind is also a good type where the reserve storage is used almost solely as an insurance to protect the plant from having to close down and will be called on only at infrequent intervals.

The machinery for this plant consists of a fixed chain-and-bucket elevator with a steel casing, and a flight conveyor arranged so that it can be rotated around a pivot point close to the elevator. The coal is dropped from bottom-dump railroad cars or from wagons or trucks into a hopper that serves to direct it into the boot at the foot of the elevator. The buckets then take it up and deliver it to the flight conveyor, which distributes it in the pile on the ground, covering the whole area over which the flight conveyor rotates.

The machinery for such an arrangement, including the motor for driving, can be purchased for about $3,000, and it would cost about $700 to erect. In addition to this there would be the cost of the concrete work and excavation, amounting, to say, $800. The two motors required

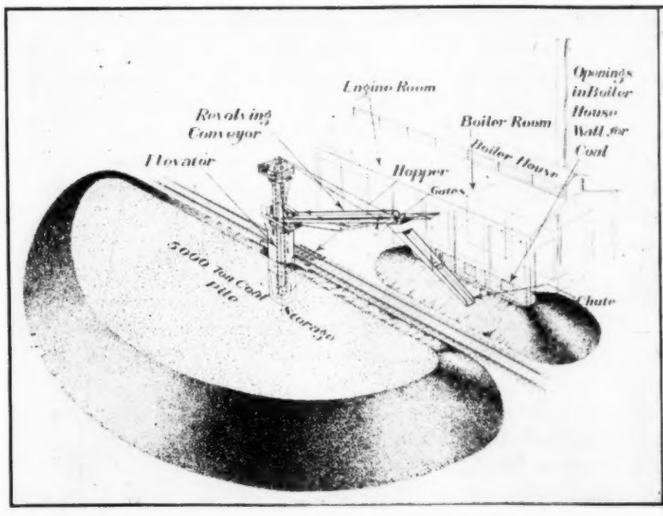


FIG. 1. EQUIPMENT FOR SMALL PLANT

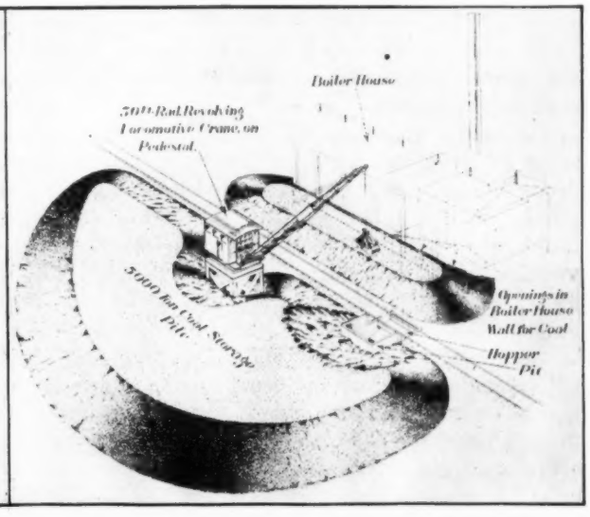


FIG. 2. LOCOMOTIVE CRANE AND BUCKET

a total of 12½ rated hp., so that an hour's run should not cost over 30c. for power, and as it requires only one man of ordinary intelligence and no special training to start and stop the machinery and feed coal to it, the hourly cost for this man should not be over 20c. This makes a total of 50c. per hr. for power and attendance, and as the capacity of the machinery is 40 tons per hr., it should be easy to handle an average of 25 tons per hr., or at the rate of 2c. per ton. This equipment is simple and therefore easy to look after and inexpensive to maintain. As stated, however, the stored coal has to be reclaimed by hand, so that if a great deal has to be taken from the storage pile each year, it is better to put in an equipment that will cut down the expense of doing this work even though the first cost is greater.

The arrangement shown in Fig. 2 consists of a locomotive crane set up on a concrete pedestal and equipped with a self-filling grab bucket. This bucket picks the coal out of a pit into which it is dumped from the railroad cars and drops it into any part of the area covered by the swing of the boom. In the same way the bucket can be used to pick up the coal from any part of the pile and deliver it alongside the boiler-room wall or into an overhead bin or hopper if desired. The cost of the locomotive crane and bucket would be about $4,500 and the cost of erection about $300. The concrete pedestal and the pit for the crane to dig from would cost somewhere around $800. This makes the total cost for the equipment about $5,600 against the total of $4,500 for the other equipment described. The crane also requires a much larger motor (about 50 hp.), but it is not running continuously when the machine is in service like that with the other equipment.

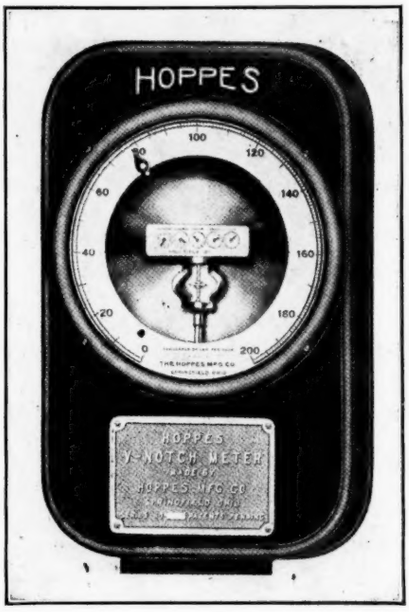
Comparison of Operating Cost

The operating cost of the crane would be about 30c. per hr. for power, 35c. per hr. for the operator and, when unloading cars, 15c. for the man who helps the coal out of the cars into the pit, or a total of 80c. per hr. It is possible to unload coal direct from some kinds of railroad cars with a grab bucket, but this is not very satisfactory except with a specially designed car. It is impossible to get the coal out of the bottoms of the usual hopper-bottomed coal cars as the crossbraces are in the way and they and other parts of the car are apt to get battered up and cause damage claims. At best there is a great deal of cleaning up necessary to entirely empty a car, and this requires a man besides the operator, so that it is usually better to use a pit into which the coal is dumped from the cars.

The hourly cost for handling would therefore figure about 80c. per hr. for the crane outfit and about 50c. per hr. for the other arrangement, but the former would probably be able to handle the coal somewhat more rapidly if the speed was not cut down by the rate at which it was fed from railroad cars into the pit. When handling back from storage, where there is plenty of coal for the bucket to dig into, the crane would probably be able to handle 60 or 70 tons per hr. and an additional man would not be required. Another point to consider is the fact that the crane operator's pay is considerably more than the other operator's, so that if the coal-handling machinery is used for only a small part of the time, it might be much harder to make advantageous use of the expensive operator for the balance of the time.

V-Notch Meter Flow Indicator

An improvement in the recorder head of the Hoppes V-Notch meter, made by the Hoppes Manufacturing Co., Springfield, Ohio, has been added in the shape of a flow



METER RECORDING HEAD

indicator on the integrating side of the head, as shown herewith. This device permits of reading the rate of flow from a distance instead of from the chart, which necessitated getting a near view of it.

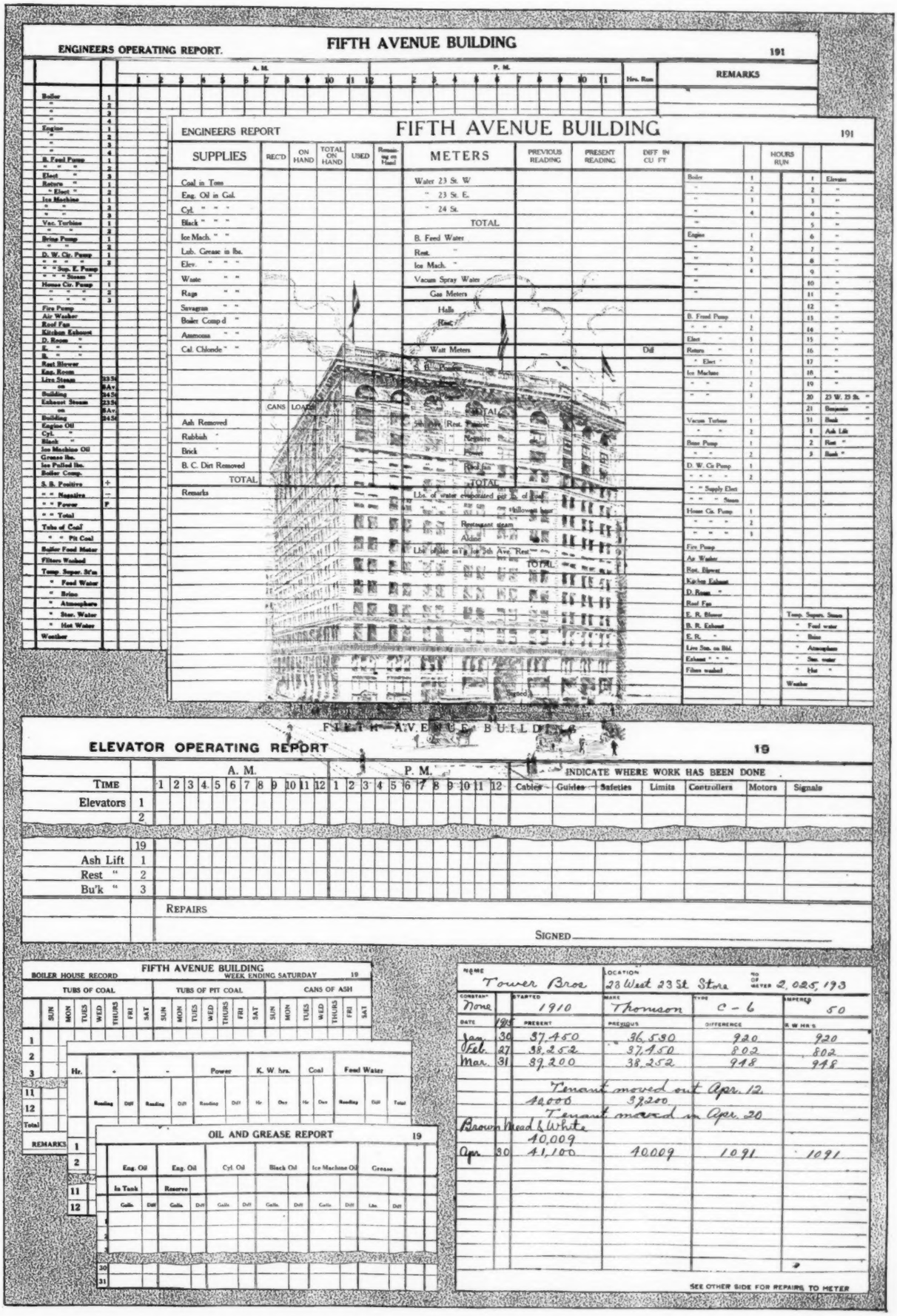
Keeping Tabs in the Fifth Avenue Building

By Charles H. Bromley

On the opposite page are shown some of the record forms used in the Fifth Avenue Building, Fifth Ave. at Twenty-third and Twenty-fourth St., New York City. The chief engineer, David Larkin, is also superintendent of the building.

One of the engineers' operating reports is filled out by each watch engineer. The length of time each boiler, engine, pump or other apparatus is run on a watch is indicated by drawing a horizontal line from the hour it was started, or from the beginning of the watch if running when the engineer came on duty, to the hour stopped or to the end of the watch if still running when the engineer went off watch. The engineers' report, second from the top of the page, is made out by the chief engineer and may be rendered weekly or monthly. As shown, it includes about all the important information needed. And that is the most desirable thing in a report sheet—to contain the items of usefulness and nothing more. The fuel used is soft-coal slack bought in cargo lots and stored in a bin under the Twenty-fourth St. sidewalk. It is burned on side-feed stokers.

In a building so large many elevators are necessary—19 here, not counting the lifts. They are all electric. The time that each is in service is indicated by a horizontal line drawn under the number of hours run, the same as for the boilers, engines, etc. This report form explains itself.



ENGINEERS OPERATING REPORT. FIFTH AVENUE BUILDING 191

A. M. 1 2 3 4 5 6 7 8 9 10 11 12 | P. M. 1 2 3 4 5 6 7 8 9 10 11 | Hrs. Run | REMARKS

Boiler 1 2 3 4
Engine 1 2 3 4
B. Feed Pump 1 2
Elect " 3
Return " 1 2
" Elect " 2
Ice Machine 1 2 3
Vac. Turbine 1 2
Brine Pump 1 2
D. W. Cir. Pump 1 2
" " " Sup. E. Pump
" " " Steam "
House Cir. Pump 1 2 3
Fire Pump
Air Washer
Roof Fan
Kitchen Exhaust
D. Room "
E. " "
R. " "
Rest Blower
Eng. Room
Live Steam on Building 225 RAv 245
Exhaust Steam on Building 225 RAv 245
Engine Oil
Cyl. "
Black "
Ice Machine Oil
Grease lbs.
Ice Pulled lbs.
Boiler Comp.
S. B. Positive +
" " Negative −
" " Power P
" " Total
Tube of Coal
" " Pit Coal
Boiler Feed Meter
Filters Washed
Temp. Super. St'm
" Feed Water
" Brine
" Atmosphere
" Stor. Water
" Hot Water
Weather

ENGINEERS REPORT FIFTH AVENUE BUILDING 191

SUPPLIES	RECD	ON HAND	TOTAL ON HAND	USED	Remaining on Hand
Coal in Tons					
Eng. Oil in Gal.					
Cyl. " " "					
Black " " "					
Ice Mach. " "					
Lub. Grease in lbs.					
Elev. " " "					
Waste " "					
Rags " "					
Savagran " "					
Boiler Comp'd "					
Ammonia " "					
Cal. Chloride " "					
	CANS	LOADS			
Ash Removed					
Rubbish "					
Brick "					
B. C. Dirt Removed					
TOTAL					
Remarks					

METERS	PREVIOUS READING	PRESENT READING	DIFF IN CU FT
Water 23 St. W			
" 23 St. E.			
" 24 St.			
TOTAL			
B. Feed Water			
Rest. "			
Ice Mach. "			
Vacuum Spray Water			
Gas Meters			
Halls			
Rest.			
Watt Meters			Dif
B. Room			
TOTAL			
Sub Sta. Rest. Passive			
" " Negative			
" " Power			
Roof fan			
TOTAL			
Lbs. of water evaporated per lb. of fuel			
" " "

A coal and ash report from the boiler room is made out weekly. Notice that apparently two kinds of coal are entered. The "pit" coal is that combustible which falls through the stoker grates and is reclaimed. The quality of coal runs uniform; the ash cans are calibrated and each is known to hold so many pounds. This coal and ash report is shown in the lower left corner. Below it is the form used by the engineers for taking meter and other readings. The oil and grease report is shown.

Each tenant has an electric meter, and a file card 8x5 in., like that shown in the lower right corner, is made out for each. This card is good for a full year except when moving in and out compels filling it like the one shown. Complaints about the meter, repairs to it, etc., are entered on the back of the card.

Complaints to the engineer's office from tenants' or other offices are received by the telephone operator, who transcribes them on a telautograph machine. The machines in the engineer's office and in the mechanics' and plumbers' shops electrically write out the orders and complaints, also the time. When these are attended to, the engineer's clerk checks them off on the roll on which the day's orders are registered.

In the engine room, in your line of vision as you go to or come from the engineer's office, is a blackboard with columns for "name," "floor," "room" and "remarks." When the steam fitter or other employee goes to room so-and-so, he writes his name, the floor and the room numbers and any remarks necessary on the board. A telephone call should reach him through the porter on that particular floor should he be wanted by the engineer.

Those who have operated know how prone some men are to leave for the men on the next watch a job they should have done. To minimize this evil a careful study has been made of the routine work—when it may best be done and by whom. Then written instructions are framed and hung near the watch engineers' desk. There can be no argument about whether "Jim" should do so-and-so this week, or whether that job is "Frank's."

Duplicates of all requisitions are filed within reach of the clerk. Material and supply charges, salaries, repair costs, etc., are entered in ledgers. Cards are also filed bearing the names and numbers of different meters, their shunts, etc.; similar cards are kept for the rest of the equipment. A yearly report sheet is kept and the sheets are bound in a loose-leaf binder.

Losses in Continuous-Current Motors and Generators

By A. M. Bennett

SYNOPSIS—An analysis of the various losses in a motor or generator and how to determine them; also typical curves showing how some of these losses vary with the load.

In the conversion of power from one form to another the output, or that available for the production of work, is always less than the input. The power lost in conversion manifests itself in some form that cannot be made useful and depends on the agency employed in making the change. The electrical power supplied to a motor is converted into mechanical power at the shaft, and the mechanical power employed to drive a generator is converted into electrical power and delivered at the terminals of the latter. In either case, however, the output is less than the input; the losses that make up the difference between the two manifest themselves in the form of heat in the various parts of the machine and are finally dissipated into the surrounding air.

The direct method of arriving at the losses in a motor or generator would be to measure the input and output and subtract the latter from the former. The input to a motor and the output from a generator are easily determined, being simply the product of the volts and amperes in either case. The motor output and the generator input, however, are not so easily determined. The former may be measured electrically by using the motor to drive a generator and measuring the output of the latter. The generator losses must be known, and these added to its output give the output of the motor. The motor output may also be determined mechanically by means of a prony brake, in which case the brake horsepower developed equals $\frac{2\pi TN}{33{,}000}$, where T is the torque as measured by the brake and N is the revolutions per minute. The watts output equals $\frac{2\pi TN}{33{,}000} \times 746$, which reduces to $\frac{TN}{7.04}$.

In measuring input to a generator a motor may be used to drive it and the input to the motor determined. The motor losses subtracted from its input gives the input to the generator. An input-output test is thus seen to be troublesome and in some cases difficult to make, and for this reason it is not much used. A simpler method is to measure the losses themselves and subtract them from the motor input to obtain the output, and add them to the generator output to obtain the input. All measurements of losses should be made with the machine hot, as this is the condition that obtains in operation. If this is not possible and cold readings are taken instead, corrections should be made to obtain the corresponding hot values.

The sources of the losses occurring in continuous-current machines are: (1) The resistance of circuits carrying current, including those of the armature, field coils, interpoles and brush contact; (2) hysteresis and eddy currents in the armature-core structure; (3) friction, including that of the commutator and bearings, and windage, or the friction produced by the rotation of the armature in the air.

The losses due to resistance of circuits carrying current vary directly as the resistance of the circuit and as the square of the current. If R represents the resistance and I the current, the loss in watts in the

circuit is I^2R, and for this reason such losses are commonly known as "I^2R" losses.

In the armature such losses are produced by the resistance offered to the armature current by the circuits or paths through which the current passes. Armature resistance can be measured directly by the drop-in-potential method, the armature being stationary when the measurement is made. The resistance should be determined after a full-load run while the armature is still hot. If the cold resistance is measured instead, the hot resistance may be found by increasing the cold reading by 0.4 per cent. for each degree that the armature temperature rises above 25 deg. C. For a final temperature of 65 deg. C., or a rise of 40 deg., the increase would therefore amount to 16 per cent. The resistance may be calculated for all practical purposes from the length and cross-section of the armature conductor, and the specific resistance of copper, the following formula being used: $r = \frac{l \times c \times 0.697}{k^2 \times a \times 1{,}000^2}$, where r is the cold resistance in ohms, l the length of an armature conductor in inches, c the total number of conductors, k the number of circuits through the armature and a the area of the conductor in square inches, the constant 0.697 being the resistance of copper in microhms per cubic inch. At a temperature of 65 deg. C., or a rise of 40 deg. above the standard room temperature of 25 deg., the resistance will be 1.16 times the value found by the preceding formula. The resistance thus found, multiplied by the square of the armature current, gives the armature I^2R loss in watts.

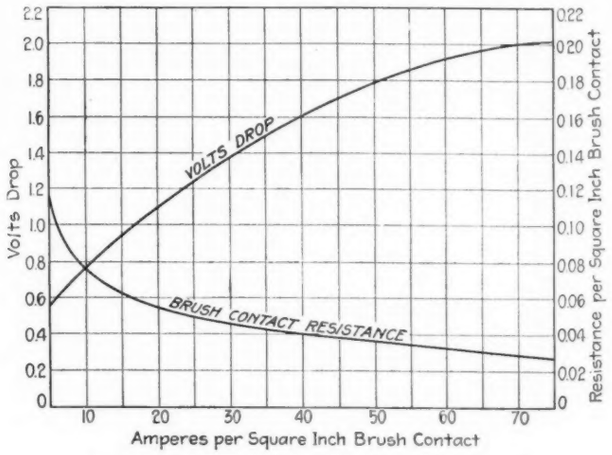


FIG. 1. BRUSH CONTACT RESISTANCE AND VOLTAGE DROP

In the field coils these losses, known as excitation losses, are due to the current necessary to produce the field magnetism and the resistance offered by the coils, which may be of the shunt or series type or a combination of both. The shunt field, being subjected to a constant potential, has in it a constant current after it reaches its final temperature. The watts loss in this case is most conveniently given by the product of the voltage across the field terminals and the field current, which should be measured while the fields are hot. In the case of a generator where a rheostat is constantly in circuit with the shunt field, it is customery to include the loss in the rheostat with the field losses. The total loss will then be given by the product of the terminal volts of the generator and the field current.

The series-field current varies with the load of the machine, and the watts loss will be given by the product of the square of the armature current and the resistance of the field windings. The resistance can most readily be determined by the drop in potential method. Interpole coils are to be treated in the same manner as series-field coils. The current in them varies with the load of the machine, and their losses are computed from their measured resistance and the load current.

Brush-contact losses occur at the point of contact between the brushes and the commutator and result from the resistance offered at this point to the passage of the armature current. There is also a loss in the commutator itself due to its resistance, but as this is exceedingly low it may be considered negligible. The brush-contact resistance and consequently the losses depend on the material of the brush and its current density, and to some extent on the pressure of the brush on the commutator, the peripheral speed of the commutator and the condition of its surface. Generally, however, the first two factors—namely, the material and current density—are the only ones considered as affecting brush-contact resistance. As contact resistance depends on the speed of the commutator, it is not possible to measure it accurately, although the drop in potential method is sometimes used. In making calculations involving this quantity, it is customary to make use of curves provided by the brush manufacturer, giving the value of contact resistance and voltage drop at various amperes per square inch of brush contact. In Fig. 1 is shown the average of such curves for several makes of carbon brushes, the voltage drop being the total for the positive and negative brushes, and the resistance per square inch including positive and negative contacts. It will be noted that the resistance of contact increases inversely as the current density; that is, when the latter is low the contact resistance is high, and vice versa. Also, at any given current density the brush-contact drop

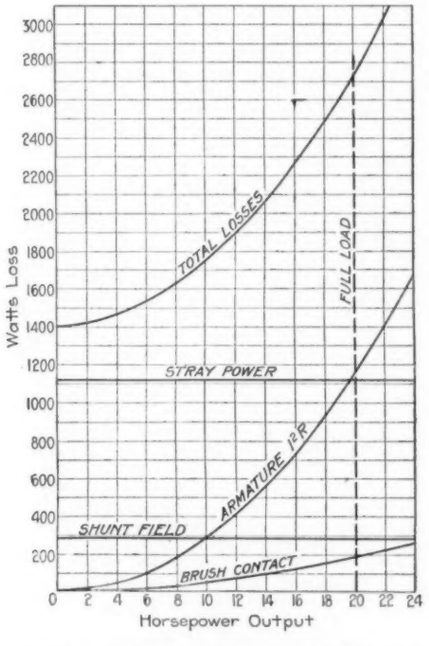


FIG. 2. SEPARATE AND TOTAL LOSSES OF 20-HP. 220-VOLT MOTOR

will be practically the same for all sizes of machines. The watts loss will be found by multiplying the armature current by the voltage drop found to exist at the value corresponding to the amperes per square inch of brush contact.

The loss from brush-contact drop is small compared to the other losses in the machine, and a slight variation from its true value affects the total loss by only a small amount. For this reason and because of the difficulty of accurately measuring this loss, it is sometimes determined by using an arbitrary value of 2 volts drop. This is the recommendation of the American Institute of Electrical Engineers for carbon and graphite brushes in the absence of definite measurements.

Hysteresis and eddy currents in the armature core introduce losses that vary with the speed and flux of the machine. They are caused by variations in flux density, and changes in flux polarity which are constantly occurring in the armature laminations, owing to the rotation of the armature. Such losses are commonly known as iron or core losses. They may be calculated directly from curves readily obtainable, such curves

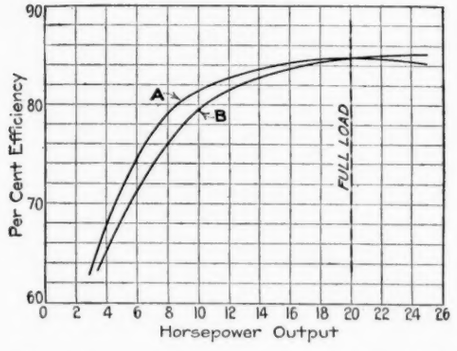


FIG. 3. EFFICIENCY CURVES FOR 20-HP. MOTORS WITH DIFFERENT CONSTANT AND VARIABLE LOSSES

showing the hysteresis loss in watts per pound of iron at one cycle per second and at various flux densities, and eddy-current loss in watts per pound of iron for laminations of various thickness at one cycle per second and at various flux densities. These losses may be measured by running the machine at no load, and the method of doing this will be described under "stray-power losses."

The friction of the brushes and bearings and that due to windage cause losses that vary with the speed of rotation. These are generally known as mechanical losses. Brush friction depends on the peripheral speed of the commutator, the pressure of the brush and the coefficient of friction between the brush and the commutator. It may be calculated from the formula, $f = \frac{s \times b \times p \times k \times 746}{33{,}000}$, where f is the friction loss in watts, s the peripheral speed of the commutator in feet per minute, b the number of brushes, p the pressure per brush, and k the coefficient of friction, equal approximately to 0.2. In estimating the pressure per brush it is customary to allow approximately 1.5 lb. for each square inch of brush-contact surface.

Losses due to bearing friction vary as the speed, while windage losses vary as the square of the speed. Both are difficult to determine by formula and are usually estimated from tests made on machines of similar type. The method of direct measurement of these losses as well as brush-friction losses, by running the machine at no load, will be given under stray-power losses.

Stray power is the term used to denote the sum of the core and the friction losses and is thus seen to include all except I^2R losses. Another term for these losses is rotation losses. The stray-power loss may be determined in one reading provided it is not necessary to know the individual losses that compose it. To make such a test, normal voltage is impressed on the field, and the machine is run as a motor without load. The voltage at the armature terminals is varied till rated speed is obtained, and the armature current and voltage noted. The product of these two gives the watts input. From this must be deducted the I^2R loss in the armature due to the no-load current. The remainder is the stray-power loss. If it is necessary to know the separate losses going to make up the stray power, the machine under test may be driven by a smaller motor whose losses are known. The machine under test is driven at rated speed, with its brushes removed from the commutator and no current in its fields. The output of the driving motor is computed, and this equals the bearing friction and windage loss of the motor under test. By making a second test, with the brushes on the commutator, the total friction loss may be determined. A third test, with the fields normally excited, gives the total stray-power loss, and this minus the total friction loss determined by the second test leaves the no-load core loss.

Four Groups of Losses

From the foregoing it is seen that the losses in continuous-current machines may be grouped from their similarity and method of determination, as follows: (a) Stray-power losses, (b) shunt-field losses, (c) I^2R losses in the armature and series windings, (d) brush-contact losses. Those in the first two groups, from the fact that they remain practically constant at all loads, are termed constant losses. Because they also occur at no-load, they are frequently known as free losses or no-load losses. Those in the last two groups are termed variable or load losses, owing to their change in value with change in load.

To represent these losses at various outputs for any particular machine, curves are generally employed as represented in Fig. 2, where the losses in watts are plotted against the horsepower output. The curves shown are for a 20-hp. commercial type shunt motor. The curve of total losses is obtained by adding together the values of the several losses as given by the separate curves.

The commercial efficiency of any machine or piece of apparatus is the ratio of the power output to the power input, or in terms of the losses it is the ratio of the input minus the losses to the input, or of the output to the sum of the output and losses. The efficiency therefore is the practical measure of the ability of the machine to do useful work and is of the highest importance to the user of power. In well-designed motors or generators of 1- to 200-hp. output it will vary from 80 to 92 per cent.

As has been pointed out, some of the losses in a machine are difficult to measure accurately, and for this reason values recommended by the American Institute of Electrical Engineers and termed "conventional" values

are sometimes assigned to such losses. An example is the 2 volts recommended as the measure of the voltage drop due to brush-contact resistance and used in computing brush losses. Where conventional losses are used in computing efficiency, the latter is known as "conventional" efficiency.

The efficiency of any machine is zero at no load, because at this period of its operation there is no output. At reduced loads the efficiency is low, on account of the constant losses—the less the output the lower the efficiency. By keeping the constant losses relatively low, the efficiency of the machine will be improved at light loads. Contrary to general opinion, maximum efficiency does not always occur at full load, but at the point where the constant and variable losses are equal. By so designing the machine that this condition obtains either at full load or before or after, maximum efficiency can be had at any point on the load curve not too widely separated from the full-load point. It is therefore possible to accommodate the machine efficiency to the load condition; thus if a machine of a given rating is to run the greater part of the time at reduced output, it can be so designed that maximum efficiency will be had at this output.

It is interesting to note in this connection that series motors have no constant losses. As the speed varies widely with the load, all friction losses will vary accordingly, decreasing with the load. Core losses that depend on the flux and speed will also vary, increasing with the load, as do the I^2R losses. The result is that maximum efficiency will occur before full load is reached.

In Fig. 3 are shown efficiency curves of two 20-hp. motors with different values of constant and variable losses. Curve *A* is the efficiency computed from the loss curves of Fig. 2, where the constant losses are relatively low, and curve *B* is from a machine having relatively high constant losses. The difference in the shape of the two curves is very pronounced. In the first it is seen that the efficiency is high at all loads and that maximum efficiency occurs at practically full load, while in the second case maximum efficiency is not had till after full load is reached.

An Extended-Surface Boiler

SYNOPSIS—Do the legs of a pot add to its heating surface? They do not increase the projected area between fire and water, but they absorb heat and transmit it by conduction to wetted portions of the surface. The article describes a small boiler in which advantage is taken of this effect, and gives the results of a test made upon it.

Yards of argument have been expended as to whether the legs of a pot add to its heating surface. They give more surface in the fire, but no more in contact with the water. The editor has recently seen a boiler in which the pot-leg effect is taken advantage of and is intensified by screwing through the crown-sheet plugs of the shape shown in Fig. 4. These are each a foot long and project 3¾ in. into the fire and between 7 and 8 in. inside of the boiler, bringing their tops about 3 in. above the normal water level.

The boiler in question is one of about 15 hp., especially designed by Enoch Rector, of the Rector Engine Corporation, 31 Runyon St., Newark, N. J., for use on a steam-driven auto truck. A cylindrical drum *A*, Fig. 3, 28 in. diameter and 10½ in. between the heads, has 177 of these plugs inserted in its lower head, as shown in Figs. 3 and 5.

Coiled around the outside of this cylinder and extending in coils a sufficient distance below it to make the confining surface of the furnace, is a ½-in. pipe through which the feed water passes. This coil is covered on the outside with asbestos cement, so that only one-half of it was counted as heating surface in the test of which the results are given farther on. The coil is then carried back and forth above the drum, as shown at *B* in Figs. 1 and 3. The feed water enters the upper coil through the pipe *C*, Fig. 1, descends through the pipe *D* to the bottom of the coil which encircles the furnace, passes upward through that coil, and is delivered by the pipe *E*, Fig. 3, downward into the center of the boiler, discharging at the water line. The superheater consists of two headers *FF* connected by semicircular loops *GG*, Figs. 2 and 3, welded into the headers and running around the inside of the firebox inside the feed-water coil, which forms its outer wall. The steam enters the superheater pipe through the connection *H*, Fig. 2, and is taken off at *I*. The burner gives a short, intense flame, the hot gases from which impinge under an air pressure of from 4 to 40 lb. into the nest of projecting cones, of which those in the center of the boiler attain a very high temperature, and threading their way radially among these cones, pass up through the spaces *JJ* between the shell of the drum and the encircling feed-water coil, bathing the superheated coils on the way and finding an exit on top of the boiler.

TESTS OF RECTOR KEROSENE-OIL FIRED BOILER

Run number	1	2	3	4
Date of test, 1916	Mar. 1	Mar. 4	Mar. 8	Mar. 6
Length of run, hr.	4½	4	4½	3
Average steam pressure, lb. per sq.in. gage	201.5	194.5	203.1	70
Average steam temperature, deg. F.	550	562.5	557	392
Average superheat, deg. F.	161.5	176.8	168	76
Average feed temperature, deg. F.	50.6	51.2	62.6	50
B.t.u.'s added per pound of steam	1,271.9	1,275.9	1,263.3	1.205.7
Actual pounds water evaporated per hour	407	436.1	306	184
Equivalent evaporation from and at 212 deg., lb. per hr.	533.2	573	399	229.41
Pounds of oil burned per hour	37.32	40.975	27.52	13.75
B.t.u. per pound of oil, high value	19,830	19,830	19,830	19,830
Actual water evaporated per pound of oil, lb.	10.9	10.64	11.23	14.1
Equivalent evaporation from and at 212 deg. per pound of oil, lb.	14.19	13.88	14.62	16.68
Over-all efficiency of boiler on high value of oil, per cent	69.8	68.47	73.65	81.33
Over-all efficiency on calculated low value of oil, per cent	74.45	73.03	78.56	86.8
Actual evaporation per square foot of heating surface per hour, lb.	5.25	5.62	3.94	2.37
Equivalent evaporation per square foot of heating surface per hour, lb.	6.88	7.39	5.14	2.96
Boiler horsepower	15.42	16.62	11.57	6.65
Average stack temperature, deg. F.	565	592	415	304
Average percentage CO_2	11.5	11.5	14	13.25
Average oil pressure on burner, lb. per sq.in. gage	35.6	40.5	19.76	4

Tests made of this boiler at the Steam Engineering Laboratory of Columbia University, by Prof. Harry L.

Parr, of the Mechanical Engineering Department of the university, were reported as follows:

During the tests the operation of the boiler was directed by Mr. Rector. The oil-supply tank was supported on a scale and connected by flexible piping. The steam generated was condensed in a surface condenser and the condensate weighed. The instruments used for determining the pressures and temperatures were calibrated and all precautions observed to insure accuracy of results. A recording CO_2 meter was connected with the stack and recorded the percentage of CO_2 every four minutes. During the first test a number of analyses of the flue gases were made by a chemist for CO_2, O_2 and CO. His readings showed the recording instrument to be correct, and he reported an average of ½ of 1 per cent. CO. During the third test, in which the percentage of CO_2 averaged somewhat higher than in the first two, no analysis was made for CO, but there was no evidence of incomplete combustion.

All readings were taken at fifteen-minute intervals including the weights of oil burned and steam generated. The conditions remained so constant that the length of time allotted to the runs was considered ample for giving accurate results.

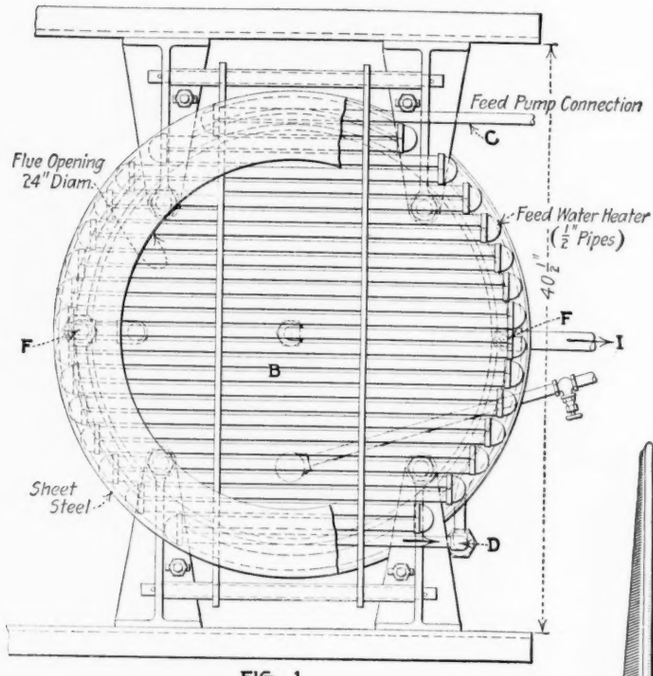


FIG. 1

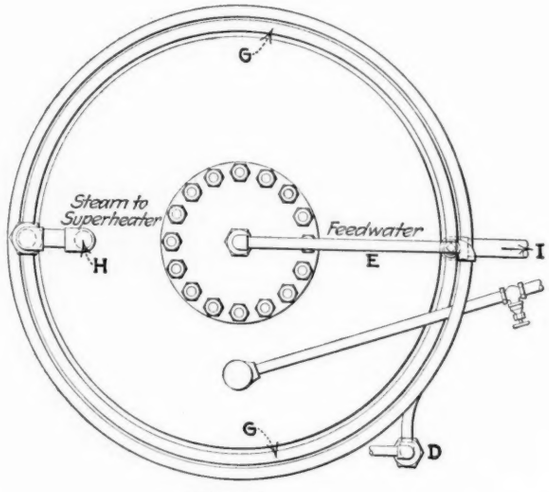


FIG. 2

FIG. 4
Detail of Heat-Conveying Plug

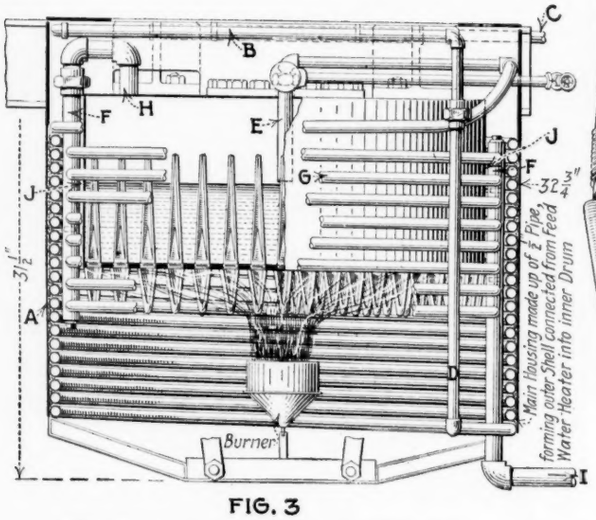


FIG. 3

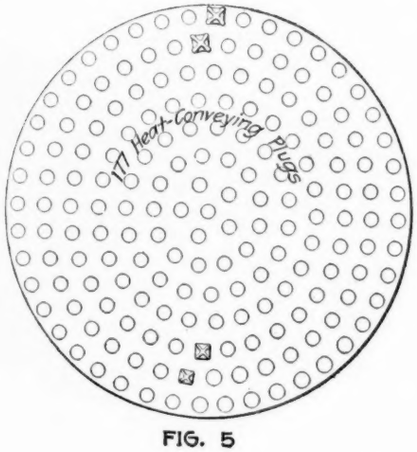


FIG. 5

THE RECTOR EXTENDED-SURFACE BOILER WITH COPPER PLUGS THROUGH THE CROWN SHEET

The square feet of heating surface was computed from the drawings. The total heating surface of the economizer sections, the boiler drum, including the copper plugs and the superheater, is 77.5 sq.ft. Of this the copper plugs make up 20.75 sq.ft., the drum 15.88 sq.ft., the bank of economizer pipes 14.39 sq.ft., the economizer coil 15.6 sq.ft. effective and the connecting pipes 2.34 sq.ft. Only one-half of the surface of the economizer coil was included, as the outside of the coil is packed with asbestos and does not come in contact with the gases.

The percentage of CO_2 recorded is nearer the maximum than the same figure would indicate for coal, because the maximum percentage of CO_2 that can be obtained when burning a hydrocarbon oil is approximately 15 per cent. This is because part of the oxygen combines with the hydrogen and burns to water.

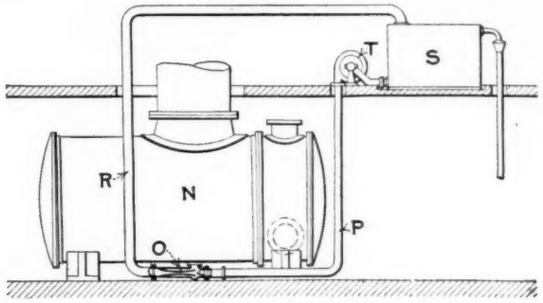
The oil used during the test was Standard Oil Co. water-white kerosene. The higher heating value was calculated by the Sherman & Kropff formula with Strong's modification, which, by comparison with many determinations by calorimeter, shows a deviation from the true values of only a small fraction of 1 per cent. The lower heating value was estimated by comparison with published values of oils similar to that used.

The test reported in the fourth column of the table was made by Mr. Rector himself without Professor Parr's assistance, but with the same apparatus and at a low rate of evaporation.

The evaporation per square foot of heating surface is computed upon the entire surface, including that in the feed-water coils and that used only for superheating. Considering the surface in the water-heating coils and the shell surface, including that of the plugs, the highest rate was over 8 lb. per sq.ft. Replacing the 20.75 sq.ft. of surface of the plugs by the 1.5 sq.ft. area of the holes they occupy, it appears that the average evaporation per square foot of projected area of surface, separating hot gases and water, was 11.4 lb. As the coil surface below the fire line is surrounded by the cool incoming air to the burner, it is of negative value as heating surface and the evaporation per square foot in other parts of the boiler must have been at considerably in excess of this rate.

Low-Headroom Condenser Arrangement

In the illustration is shown an arrangement that according to *Mechanical Engineering* is designed by Stark & Co., of Hengelo (O), the Netherlands. Its purpose is to permit of placing a condenser in the basement of an engine room without the necessity of going



ARRANGEMENT OF CONDENSER IN BASEMENT

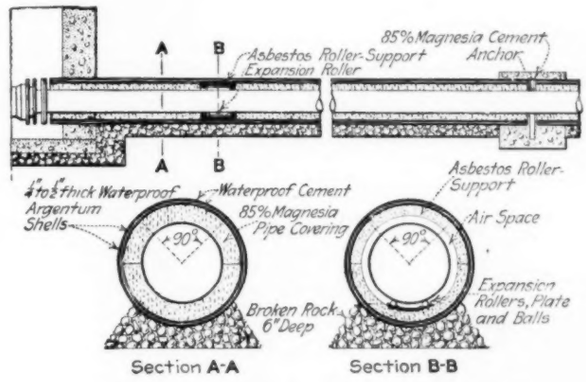
to a depth sufficient to accommodate the circulating and wet-air pump.

The condensate pump may be placed at any height, the condensed steam being drawn from the condenser by a water-jet ejector worked by a pump supplied with condensing water from the condenser, and at the same time the different pumps of the plant may be combined with the condensation water pump in one aggregate set. The condensed steam flows from the condenser N to an ejector O, which receives power water under a suitable pressure through the pipe P. The mixture of condensed steam and jet water is discharged through the pipe R into a cistern S, from which a centrifugal pump T delivers the water into the pipe P.

The cistern S has an overflow to keep the quantity of water in this closed system constant by wasting the equivalent of the steam condensed. The centrifugal pump may be mounted on the engine floor and combined with the circulation-water pump and the dry-air pump in one set if the suction height of the circulation water pump does not prevent.

Carey Underground Insulation

To insulate steam or hot-water underground piping the Philip Carey Co., of Lockland, Ohio, has recently applied some of its standard products. The insulating medium is a standard thickness of 85 per cent. carbonate of magnesia. To prevent moisture from interfering with



DETAILS OF UNDERGROUND INSULATION

its high insulating value, the covering is waterproofed by a double layer of Argentum shells. These shells are split on one side only and are intended to be sprung over the pipe covering. In this way there is only one horizontal seam to seal in each shell, and by applying the two layers of shells so that no seams or joints of one layer coincide with those of the other layer, there is no direct opening through any of the outer seams to the insulating covering.

The magnesia covering is applied in the usual manner, the different sections being butted closely together with all seams horizontal. At the end of every five sections (15 ft.) an asbestos support, with roller plate and balls properly inserted, is provided. Over this magnesia covering and the asbestos roller support the first course of Argentum shells is applied so that no seams or joints coincide with those of the magnesia covering. The seams are drawn tight with a rope in the form of a tourniquet and stapled together at intervals of 2 in. The butting sections are also stapled together. A coat of Carey universal cement is applied to the outer surface of the first course of Argentum shells, and the second course is then applied, breaking all seams and joints, as previously described. The covering is finished with a heavy coat of cement. Where the ground is unusually moist or marshy, a final coating of coal-tar pitch is applied.

At stated intervals anchors are attached to the pipe. The covering is fitted as closely as possible to the anchors,

and the space between is filled in with magnesia cement. Over the anchor and extending at least one foot over the pipe covering on each side is cast a solid block of concrete. To provide for drainage a bed of broken rock not less than 6 in. deep is laid in the bottom of the trench, and at manholes and low points of the trench tile drains to sewers or other points below the level of the trench are provided.

From the accompanying illustration and the foregoing description it will be apparent that the covering and waterproofing are easily applied. They are light and efficient, and as there is no concrete except at the anchors, the installation work in the trench is reduced to a minimum.

The Converter Sparked

Synchronous converters, as formerly constructed, were prone to flash over from brushholder to brushholder or from a brushholder to ground, in machines that were operating on ground return circuits. This was a weakness of the machines of higher frequency, and the machines of lower frequency were not immune.

That this trouble has been almost entirely eliminated is due partly to the improvements in design, to education of the operators and to a realization of the fact that a converter that is designed and adjusted for specified operating conditions will give better satisfaction under those conditions than under any other and will require less attention. Even when the conditions of current, frequency, alternating and continuous voltages and degree of compounding have been specified, it is sometimes necessary to refine the adjustments after the machine has been installed. The factor most likely to be abnormal is the voltage applied to the alternating-current end, because it may have been affected by transmission changes that occur between the time of specifying the operating conditions and the time of placing the machine in service.

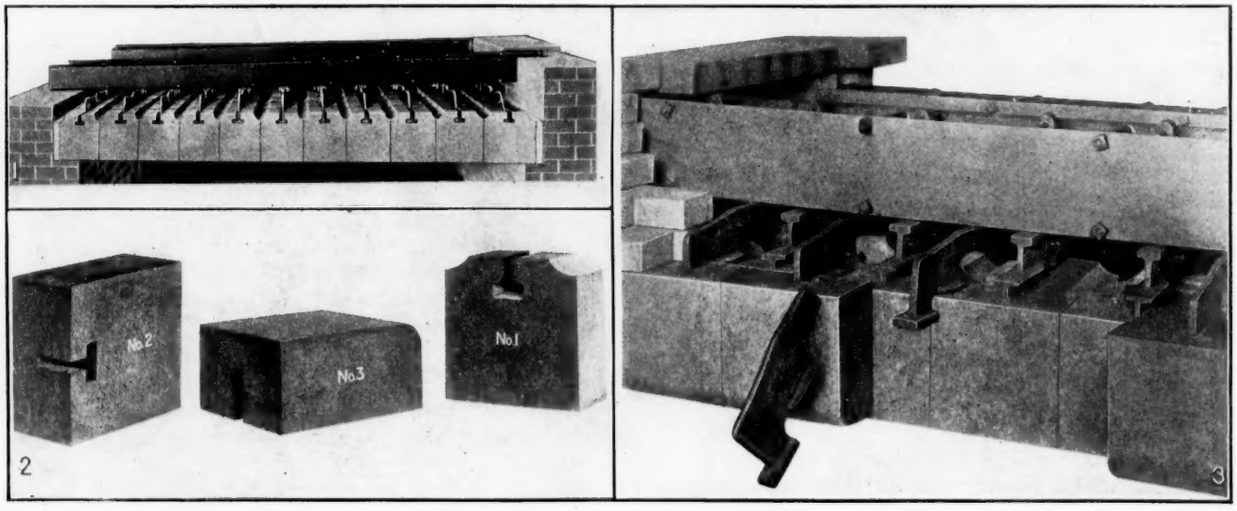
An operator complained of the sparking of a converter that had been in successful operation for several years. Investigation disclosed that the operating conditions had changed. The converter and the transformers from which the converter drew its energy formerly had been separated by several miles of transmission lines. A new source of power had become available, and the transformers had been moved to a location near the converter. It was after this move that the converter gave starting troubles and showed a tendency to flash over whenever any condition approaching a short-circuit occurred on the line.

On changing the transformer connections to other taps that subjected the converter to the voltage at which it had so long operated, no further trouble was experienced.

The Detrick Suspended Arch

A suspended flat arch which is adaptable not only to the general field of chain-grate stokers, dutch ovens, etc., but which may also be used with Stirling boilers and side-inclined stokers, has recently been placed on the market by the M. H. Detrick Co., 547 W. Washington St., Chicago. As shown in the accompanying illustrations, the arch is made up of specially formed tile centrally supported by a flexible arrangement of ironwork. Special precautions have been taken to protect the supporting members from the heat of the furnace. This applies not only to the main body part of the arch, but also to the inner end, which is subject to the greatest wear and tear. The inner end is protected by special end tile Nos. 2 and 3 in Fig. 2. As shown in Fig. 3, No. 2 tile cover the ends of the arch bars. In addition there are special end tile which stagger the joints between the tile in the main body of the arch and are supported by the separate castings, shown in Fig. 3. Other castings at this point support the apron wall extending up from the rear end of the arch. Should the end tiles burn off, only the short castings will be destroyed, leaving the main supporting members intact and protected by the second end tile.

From the detail views of the chain-grate ignition arch shown in Fig. 4, the flexibility of its construction will be evident. The arch bars supporting the tile offer several places of attachment for the hangers, the latter being upheld by steel pins resting on channel-iron supports. The space between these channels allows considerable leeway for the hangers, and at the sides of the arch a loose packing of asbestos takes care of the expansion of the



FIGS. 1 TO 3. DETAILS OF IGNITION ARCH ABOVE THE GRATES

Fig. 1—Ignition arch over chain grate. Fig. 2—Forms of tile used. Fig. 3—End tile protection at rear end of arch

tile. The latter feature relieves any internal stress in the tile and prevents sprawling, which might result if the construction was too rigid. There is no thrust on the side walls, and as each row of tile is supported separately, the erection of the arch is simple. Specially long arches are made in two sections, so that repairs can be made at either end or at the center without removing many of the tile. In single Stirling boilers where the entire arch is within the walls of the boiler, the supporting channels are carried through the boiler walls to the outside so that air may circulate through the channels and keep the supporting members relatively cool. When the boilers are set in battery the air ducts between the channels are connected together in the center wall, allowing a free passage of air through these ducts without admitting air to the furnaces.

In these days when boilers are forced considerably above rating and the service is particularly destructive of brick-

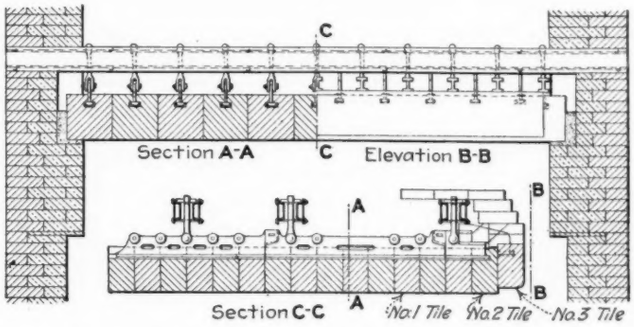


FIG. 4. DETAILS OF CHAIN GRATE IGNITING ARCH

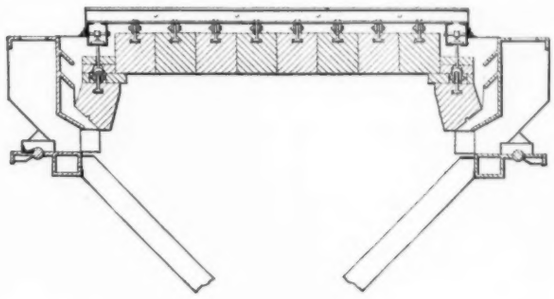


FIG. 5. ARCH FOR SIDE INCLINED FURNACE

work, an arch in which any single element can be readily renewed by unskilled labor has a decided advantage. With the construction under consideration it is claimed that the maintenance is unusually low, the repairs being limited usually to the renewal of the end tile instead of the entire arch reducing the time lost from service.

Welded Offset Pipe Connections

SYNOPSIS—Oxyacetylene welding in ordinary repairs makes it possible to handle a great deal of work more economically and more efficiently than by older methods.

A recent sprinkler-pipe installation handled in the Indianapolis plant of the Prest-O-Lite Co., Inc., necessitated the running of branches from the 6-in. water main of the sprinkler system in the company's plant. Because the main had been hung close to the ceiling, offsets in the branches were required to clear the concrete girders and other piping already in place.

The usual procedure of employing ordinary screwed fittings was started until it was found that on one side a drop of 7½ in. was required, making the use of standard fittings with 6-in. pipe impossible. The connection was finally made by using regular 45-deg. flanged elbows and nipples, giving the pipe a 12-in. drop.

The cost of the offset effected in this manner, including all of the necessary parts and labor for connecting the job, was $17.50. Had it been possible to make the offset with standard screwed fittings, the job would have cost $5.66.

The branch on the opposite side of the main, however, presented an altogether different problem. A downward offset of exactly 5¼ in. was necessary to clear pipes above and below the new line. Standard fittings, either flanged or screwed, could not be used, and an estimate was obtained on the cost of bending the pipe for the required offset. It was found that this method would cost $18.60, including the bent pipe and labor for connecting. Fur-

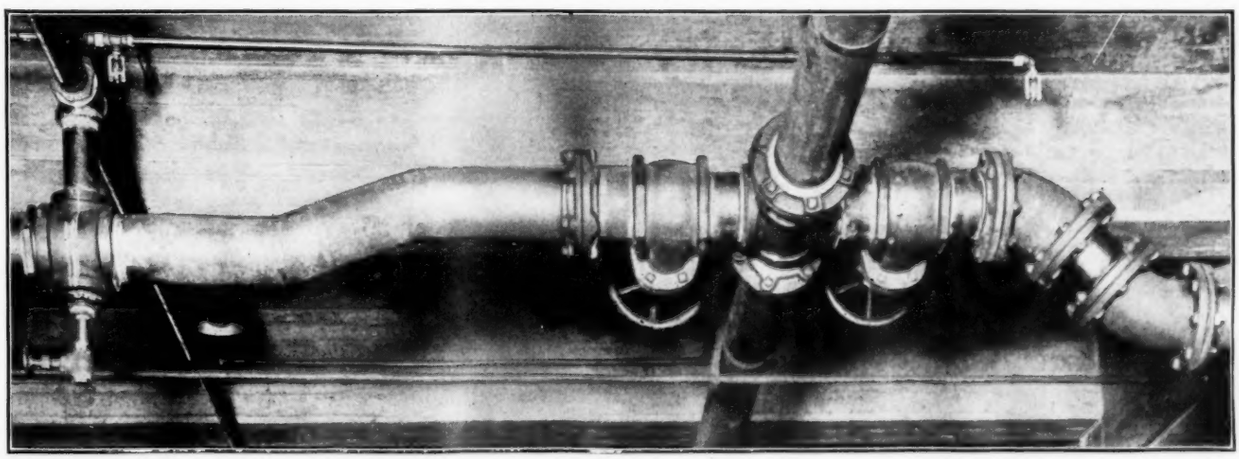


FIG. 1. OFFSET ON LEFT OBTAINED BY WELDING; ON RIGHT BY FITTINGS

thermore, a considerable delay would have been occasioned waiting for the pipe to come from the mill.

The idea of employing oxyacetylene welding was then suggested by one of the factory employees. A short section, cut at each end at the proper angle to give the offset desired, was welded into the line at a total cost of $3.40, as compared with the cost of $17.50 for the flanged job and the $18.60 estimate for the bent pipe.

The view in Fig. 1 shows two methods of obtaining the offset—the one on the left by welding and the one on the right by using flanged fittings. It will be observed that the welded connection, in addition to its greater economy, is neater in appearance and occupies comparatively little space.

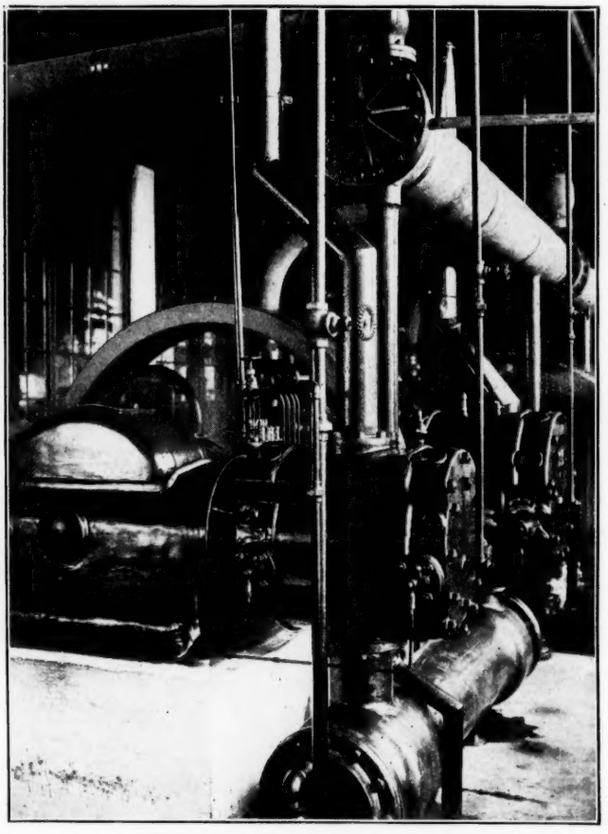


FIG. 2. WELDED AIR-COMPRESSOR PIPE LINE

Another instance of welding pipes is shown in Fig. 2—that of the discharge pipes of an air compressor. The air pressure carried was 110 lb. per sq.in., and the pipe was 5 in. diameter, with offsets of 45 deg. Owing to the proximity of other pipes the ordinary flanged fittings were impracticable, and the offsets were made with welded joints as shown. Another advantage of the job is that the chance of air leakage at the joints has been eliminated and a neat appearing pipe line is had.

Radiation and Condensation Tests, conducted by G. M. Brill on pipe carrying low-pressure steam when bare and again when covered, showed an average heat loss for bare pipe of 2.7 B.t.u. per hr. per sq.ft. per deg. difference in the temperature of the steam and the surrounding air, condensing 0.0031 lb. of steam per hour. The average of a large number of tests with six different kinds of coverings under similar conditions showed a heat loss of only 0.3328 B.t.u. per hr. per sq.ft. per deg. and 0.00038 lb. of steam condensed per hour, or about 8¼ times as much loss from bare as from covered pipe.

JUST FOR FUN

Waterproof Boilers

The following want advertisement recently appeared in a Brooklyn, N. Y., newspaper:

ENGINEER, experienced, with high speed engines, dynamos and waterproof boilers; must be strictly sober and steady; plant located in Brooklyn. Apply 532 E. 76th St.

Wonder what waterproof boilers are like.

The Professor Was Wrong

A professor of mechanical engineering in a state university recently read quite an involved paper, at a state convention of engineers, upon the percentage of CO_2 in flue gas. After the meeting, he overhead one of a group of engineers standing about the hotel lobby remark:

"That stuff that college professor told about is all bunc. I've been firing a boiler for 30 odd years and I've never even seen a B.t.u. or a CO_2 about the place!"—Harlan A. Russell, Lawrence, Kan.

Stopping the Pop

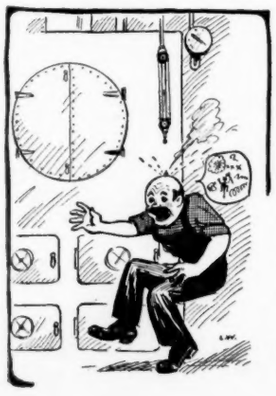
The pop safety valves of some water-tube boilers discharged into the boiler-room, much to the annoyance of an Italian fireman who did not like the noise. One night the engineer found the fireroom deserted and the water in one of the boilers falling fast. Going to the rear of the boilers, the fireman was found with the blowoff valve open. When asked the reason for blowing down the fireman said, "She pretta soona pop; I blowa da steam outer de side."—John C. Morton, Wendel, W. Va.

Let the Boiler Breathe

The steam fitter-master mechanic at a meeting heard a discussion on the breathing action of boilers. He forthwith told the "chief" that boilers breathed the same as humans. Two weeks later the master mechanic found that a hole about 4 ft. square had been cut in the brick wall level with the top of the boilers, through which cold air was whistling. Upon inquiry the fireman said the chief had the hole cut because boilers breathed, and that anything that breathed had to have fresh air, and he wasn't going to have his boilers suffer. It was so hot on top that he could hardly breathe himself, and so how did anyone expect a boiler to?—W. M. Stockwell, Middletown, Conn.

Thought It Was Hotter

The fireman came into the engine-room scratching his conspicuously bald head and asked, "How hot is the water in the boilers?"



"About 355 deg. F.," replied the engineer.

"Gosh, is that all?" he exclaimed; "I thought it must be at least twice that. Just as I bent over to look into the firebox of No. 1 boiler a drop from the gage-cock landed on my bean. Only 355 deg. H——! I got the impression it was hotter than that!"—H. G. Gibson, Washington, D. C.

Editorials

Friction of Riveted Joints

On another page of this issue appears a letter from a reader on the practice of including the shearing resistance of the rivets in determining the strength of riveted joints.

This argument about the slippage of riveted joints is advanced from time to time, and its advocacy is apparently due to lack of a thorough understanding of the significance of the relation that should exist between the ultimate strength and the working stresses in a material or structure.

It is unlikely that anyone familiar with the testing of riveted joints, or who may be conversant with the behavior of such joints when applied to a vessel and subjected to hydrostatic test, can be under the impression that a load approaching the full strength of the joints may be applied without producing ruinous distortion. The calculation of the ultimate strength of a riveted joint for the purpose of design is merely useful as supplying a figure to which a safety factor may be applied for the determination of the safe working pressure—merely something to tie to.

In stating the ultimate strength of a joint, it should be in no wise implied that it would ever be possible to attain this value under working conditions, as this is not practicable.

The ultimate tensile strength of a material is used as a basis upon which to fix the safe load on the tension members of a structure composed of that material, though it is understood by all that the structure would be rendered useless, because of deformations, long before this ultimate strength was reached. Practically all engineers agree that the elastic limit of a material would be a more logical basis upon which to determine the safe working load than the ultimate strength, if the true elastic limit could be accurately determined by test. With present methods of testing materials it is not possible to determine this property of a material or structure with nearly the same degree of accuracy as the ultimate strength may be determined.

The same thing is true of riveted joints; that is, with the tensile and crushing strength of the plate and the shearing strength of the rivet material known, the ultimate strength of a riveted joint may be determined with a fair degree of accuracy, while the load at which distortion would occur due to slippage at the joint or from other causes, that would render the joint unfit for further use, would be uncertain.

The ultimate strength of riveted joints is therefore likely to remain as a basis for the fixing of safe working pressures for riveted shells. The application of a safety factor should consist of the division of the most constant factor connected with the failure or partial failure of a structure or its parts, by a figure that experience has shown to give a working load that may be used with safety. To obtain consistent results the feature of failure or partial failure that has been demonstrated by tests to yield the most uniform results should be chosen as the base to which the safety factor should be applied.

The fact that a boiler joint would become useless from deformation before actual failure of the rivets by shearing could take place should have no bearing on the question of whether the ultimate strength of such a joint is a proper basis for fixing the safe working pressure, but rather what the factor of safety should be. However, a factor of safety, for other reasons, is chosen which will bring the working stress well within the point where a slippage of the plates might be expected.

Safe Discharge Pipes for Safety Valves

Short, direct and unobstructed discharge pipes for safety valves would seem to be almost self-evidently necessary. Yet a recent instance of improper practice in this respect suggests the importance of commenting upon the matter. The inspector of an insurance company, while examining a boiler, found that a whistle had been attached to the end of the discharge pipe from the safety valve since his last visit to the plant, and that a stop valve had been placed between the safety valve and the whistle. Obviously, with this stop valve closed, the safety valve could not operate in the event of over-pressure, and a serious accident might occur. The safety of the employees in the entire establishment was made to depend solely upon the faithfulness and intelligence of the boiler-room attendant. Surely such a condition should not exist.

Placing valves of any kind in the discharge pipes from safety valves has been repeatedly warned against, and in the pipes themselves, short turns and bends should be avoided. Care should also be taken to see that the pipes are never smaller in area than the valve areas to which they are connected. When possible, such pipes should be extended nearly horizontally to some point in the boiler room where the escaping steam will not be objectionable. With this arrangement, the fireman is certain to hear the steam escaping and know that one or more valves are blowing, whereas he might not immediately notice it if the piping discharged outdoors.

In installing safety-valve discharge connections, the piping should be erected on a slightly descending grade away from the safety valves, so that the water of condensation will be automatically drained away from the pipes and the upper parts of the valves. If the pipes must be extended vertically, open drains of ample size should be provided at the lowest points. Special care is necessary in the winter to prevent the condensation from freezing in the discharge piping that may be exposed to the outer air. It should not be necessary to add that such piping must never discharge into passageways, either inside or outside the station building, or into work rooms or at other points where persons are likely to be endangered by the escaping steam.

Precipitate Action Invites Error

An engineer in charge of a factory plant had installed a number of expansion steam traps. These were exactly suited to the conditions they were intended to meet, and had therefore given satisfaction. The engineer's supervision was extended to take in a newly erected plant of a character quite different from the one with which he was already familiar, and he was given carte blanche in the matter of its equipment. The requirements of the prospective service called for the installation of a large number of steam traps. Without pausing to see if there were any peculiar conditions that might call for a different style of trap and remembering only the excellent results obtained with the equipment in use in the factory plant, he went blindly ahead and placed an order for traps of the same kind for the new job. When the plant was started, the equipment was found to be practically useless. The selected steam traps had to be discarded in favor of new ones adapted to the special requirements of the service.

This incident shows that the selection of apparatus cannot be regarded safely as a general proposition. As a matter of self-protection, if for no other reason, the engineer must give each detail separate consideration and search out every circumstance that may have a bearing on the case. He cannot afford to recommend the purchase of any piece of apparatus until he has thoroughly investigated and weighed all the conditions to be met, because this is work wherein a man's mistakes stand as enduring monuments to lack of skill or judgment.

Chief engineers nowadays are looked to by their employers for expert opinion, and while experts in some lines of scientific endeavor may escape the contumely attaching to erroneous decisions by beclouding the issue with theoretical conjecture and speculation, the engineering expert has no such refuge. His blundering unfailingly leads to his discomfiture, for it all hinges upon a question of whether the apparatus is proved by trial to be suitable for the purpose intended.

The engineer's special province is, of course, the power-producing department of the works—the boilers and engines and electric generating equipment. There was a time when it was considered the height of presumption for an engineer to show any interest in what transpired in the power-consuming end of the establishment, the selection of apparatus of whatever character for use in departments beyond the engine room being regarded as a prerogative of the superintendents and foremen in those departments.

But the status of the modern chief engineer is altogether different. In matters pertaining to power, whether in the production or consumption thereof, his influence extends to all departments of the establishment. When it comes to planning the installation of new apparatus, he is often required to take account of many features of the plant, as a whole, that are only remotely connected with his own special department. Not alone does the generation of power comprise the sum total of his interest in the business; the transmission and use of power likewise call for his attention, and where equipment is selected without due regard for conditions that may distinctly affect these items, trouble is apt to be forthcoming. In the episode of the ill-adapted steam traps, unconsidered external circumstances were mainly accountable for the unfortunate selection.

Normal Voltage and Lamps

In an office building served by an isolated plant a system of indirect lighting was installed. The owner agreed to maintain the lighting fixtures, to care for the cleaning of lamps and make replacements; these tasks, with the supply of current at normal voltage being detailed upon the local operating engineer. Inquiries as to the character of service the installation was giving tenants brought out the point that the latter were not wholly satisfied with the resulting illumination. The manager of a large insurance organization occupying the street floor and served by sixteen 150-watt tungsten lamps stated that it was frequently necessary to call upon the engineer to speed up the engines so that the lamps might get the benefit of normal voltage; that when the plant was temporarily shut down and service supplied through a breakdown switch by the local electric light company the voltage conditions were greatly improved, and finally, that insufficient attention was given to cleaning and lamp renewals.

In justice to the engineer who has to render service to such an installation, it may well be emphasized that indirect-lighting units are difficult to keep clean, the bowls forming natural catch-basins for dust. A ceiling of dull tint also is a handicap to efficient reflection. In the stress of other work, it is very easy, also, to let the almost imperceptible sag in candlepower of the tungsten lamp accumulate in service without considering the expediency of replacements with new bulbs. But it is a severe indictment when the charge of subnormal speed of generating units is leveled against the operating man, and so far as is within his power, it should be impossible for any consumer in a building where no serious fluctuating motor load exists justly to claim that outside service is superior to that delivered by the local plant.

Tenants are becoming more critical of voltage conditions at their lamps, and the problem of maintaining normal pressure is one of the most important with which the engineer can concern himself in competition with the offerings of the outside company. Where an installation is naturally difficult to keep at the most efficient point, as where all indirect lighting is used, extra attention must be paid to the foregoing conditions in order to deliver the standard of service that may properly be required by the consumer. The policy of the owner should be to back up his engineer to the limit in supplying new lamps, whether gas-filled or straight tungsten, when these are plainly needed, and the responsibility for cleaning such units should be fixed and then met with faithful service.

⁂

When a man says he can judge the quality of coal by the way it makes the shovel ring, be assured he calloused his hands to learn how.

⁂

Of course no one expects engineers to perform physicians' duties, but those in charge of building plants where the air is heated, cooled and humidified can, by intelligent or ignorant use of the "conditioning" system, minimize or extend the occupants' sick list. Do you know what percentage of humidity is best for your building, its occupants and furniture?

Correspondence

The Thinker

In *Power* of Feb. 29 appeared a poem, "The Thinker," by R. T. Strohm, which I discussed with my wife in various directions. As a result she prepared an answer apropos of the present times and conditions, which I told her I would send you as I considered it quite "taky."

THE THINKER TODAY

There once was a story that plenty of glory
  Awaited the fellow who worked with his brains;
But the duffer who'll do it is certain to rue it
  And hasn't the sense to come in when it rains.
He'll find it a fable that men who are "able"
  May rise o'er the level of negro and chink;
Along with all beauty in doing your duty
  Have vanished the honors of fellows who think.

This land is fast filling with chaps who are willing
  To buy soul and body where labor is sold;
Gray matter in action has now no attraction,
  The world only worships its idols of gold.
You work at high tension to make an invention,
  The patent is stolen before you can wink;
Your sole chance of honey is heiring big money,
  No laurel crowns now for the fellows who think.

He's only succeeding who's clever at bleeding,
  Whose heart and whose conscience have both died of rust;
No sight is there sadder than climbing Fame's ladder,
  The rooms at the top are all cinched by the Trust.
You're planning and turning and genius burning,
  You'll find that Success is a mythical minx;
From black to albino, unless he's the rhino,
  There's only a club for the fellow who thinks.

If Watt and if Newton, with ideas a-shootin'
  The length and the breadth of each well-furnished skull,
Were now to live over and try to discover
  A law or a force yet unknown to the dull,
Unless they were willing to undergo killing,
  They'd better not find any long-missing links,
For decapitation and annihilation
  Are now the rewards of the fellow who thinks.

Erie, Penn. H. A. WILDE.

Friction in Riveted Joints

In reading *Power* of Mar. 7, I find that in two instances the calculation of rivets for boiler joints is based upon the shearing strength of the rivet shaft. Basing the calculation of rivet joints and rivets on the shearing strength of the rivet is not correct.

More than fifteen years ago Prof. Carl von Bach proved conclusively that the friction of the plates must be considered the dominating factor of transmission of the stresses of a rivet joint, otherwise a calculation of the joints is, at best, problematical.

The rivets, driven in while hot, contract while cooling and do not fill out the rivet holes. Especially in butt joints with two plates is this true; thus a slight movement of the joint must precede the action of shearing of the rivet shaft. However, as a joint that permits the slightest movement must be considered faulty, the shearing stress of rivets cannot be considered in calculations of joints that must be rigid, as in boiler work and hulls, where the tightness of the joint is endangered by the slighest movement.

I mention this only in the way of illustrating the unreliability of a calculation of rivet joints based upon the shearing stress of the rivets. There are a number of other reasons why our practice in this regard should be condemned.

Why do we continue along lines so palpably wrong and which were long ago abandoned in Europe? Is it a lack of thoroughness in our work or unwillingness to study and profit by developments in other countries?

Chicago, Ill. JOSEPH GODER.

[This idea of frictional resistance in riveted joints is advanced from time to time, but should not disturb the conception or practice of the reader. See the editorial on page 625. Discussion is invited.—Editor.]

Explosion in an Ash Tank

In the Apr. 4 issue, a letter on "Explosion in an Ash Tank," by L. C. Kramer, appears, in which he asks for a reason for the explosion. It no doubt happened because hot ashes were being handled containing some coke and unconsumed coal which, owing to the heat in the tank from the hot ash, gave off the volatile matter in the coal, such as hydrogen, hydrocarbons and carbon monoxide. Upon opening the gate to discharge the ashes, these combined with the oxygen of the air which rushed in to take the place of the ashes discharged and formed an explosive mixture. This was ignited either by the heat in the tank or by some of the hot ashes.

In the seven years that I have operated the vacuum ash-handling system, I have had but four explosions in the tank, and each time hot ashes were being handled without water. Fortunately no one has ever been injured.

I would suggest to Mr. Kramer that instead of loose plates set on top of the tank he provide four or five 8-in. outlets with caps or bonnets, fastened with a small length of chain, on the downcomer between the tank and the dust collector. Then, when an explosion occurs, the caps or bonnets are blown off, releasing all pressure, and they can be immediately replaced.

An explosion has never occurred when the spraying water was being used, no matter how hot the ashes.

Philadelphia, Penn. ALEXANDER ARNOIS.

I read with interest L. C. Kramer's experience with his ash-handling equipment as told in the April 4 issue. Personally, I am not familiar with any of the so-called vacuum ash-handling systems, but from the excellent description presented by Mr. Kramer, I can readily understand the nature of his equipment.

As it appears to me, during the period that the pump was in operation, all the ashes entering the tank were wet. Then, from some cause or other, the pump stopped, thereby cutting off the water supply, and resulting in the following condition: All the ashes, just as they left the fire—some at red heat—were sent into the ash tank on top of the wet ashes; the steam generated by the wet

ashes percolated through the hot dry ashes and, while so doing, became dissociated into its competent elements, hydrogen and oxygen. Some of the oxygen, combining with the free carbon in the ashes, formed CO; but part of it again entered into a mixture with the hydrogen, and, since the combination of hydrogen and oxygen in certain proportions is highly explosive when ignited, the foregoing seems the logical cause for what happened.

Another possibility is that the coal used by Mr. Kramer contained a quantity of pyrites which, when burned, formed H_2S, and this, carried in the ashes to the tank, was there combined with air, forming an explosive mixture.

FREDERICK HANSA.

New York City.

What Caused the Pressure Fluctuation?

I read with interest the inquiry by Charles Haeusser, in the issue of Feb. 22 relative to what caused the pressure gage to indicate a fluctuation in the pressure then existing in a horizontal tubular boiler. As he has stated, the boiler had been out of operation for 18 hr. and the gage still showed 40 lb. and the safety valve was operated for a moment to ascertain that the pressure was due to steam and not to air. After a wood fire had been kept going for a half-hour the gage indicated a drop in pressure from 40 to 30 lb., where it remained for 10 min., after which it increased regularly until 80 lb. was attained, when the boiler was cut in service.

I have found that the teeth of the pinion, which mesh with those of the sextant connected to the spring of the gage, become worn and will catch, one on the other, causing the gage to become temporarily inoperative. Also, a small piece of matter falling into the mesh of the teeth will cause the gage to stick. A slight shock imparted to the gage by tapping will cause it to operate again.

It is probable that one of the faults mentioned caused the gage to remain at 40 lb. although there may have been only 15 lb. steam pressure in the boiler. After the fire was started and kept going for a half-hour, it is reasonable to assume that the boiler was generating steam, owing to steam pressure being present before the fire was started. During this half-hour the steam pressure was increased to 30 lb., at which time the gage may have received a slight shock causing the mechanism to become free and allowing the hand to drop back to the pressure then existing, which was 30 lb. The movement of the spring due to the increasing pressure may also have had a tendency to cause the pinion operating the hand to release itself.

C. E. KLING.

Allentown, Penn.

Instrument Limitations

Instructions on the use of instruments in tests always should emphasize the limiting conditions that the current coils of ammeters, wattmeters and watt-hour meters should not be subjected to currents exceeding their capacities, and that voltmeters and the potential coils of wattmeters and of watt-hour meters should not be subjected to voltages greatly exceeding their ratings. Instruments are especially liable to injury where the existing conditions of the circuit that is being tested are not known, or where known conditions are changed as the result of a circuit irregularity that develops during the test. The following illustrates the latter source of abuse, in that the application of the instrument closed a circuit:

An operator of several 440-volt direct-current generators experienced difficulty in getting one of them to generate. Preceding the failure to generate, the machine had for some time been slow and erratic in "picking up" its field magnetism. This trouble was wrongly attributed to short-circuited field coils because the operator had had such trouble on another occasion. In taking the voltage drop per field coil, a 150-volt voltmeter was used. Ordinarily this would have been of ample range, but in this particular case the failure to generate was due to an open-circuit in a jumper between two of the coils, and as soon as the voltmeter lines were applied across this break, apparently the voltmeter burned out because it was subjected to the full 440 volts of another machine to which the field circuit was connected during the test.

Schenectady, N. Y. E. C. PARHAM.

Distinguishing Pipe Lines

In the issue of Feb. 8, 1916, page 196, Mr. Connor suggests stenciling colored arrows on the various lines of a piping system. The colors as given do not conform to, nor are they as extensive as, those recommended by the A. S. M. E.,[1] which many of the larger companies have adopted. A synopsis of the committee's report is as follows:

Paint all pipes in well-lighted main engine rooms to conform to the color scheme of the room. If desirable to use distinguishing colors, these should be painted only on flanges and on valve and fitting flanges. All fire lines (suction and discharge), valve flanges and fittings shall be painted red throughout. In all other parts of the plant, such as boiler house, basements, etc., paint the piping (exclusive of valves, flanges and fittings) black or some other durable, inexpensive color.

The edges of all flanges, fittings or valve flanges on pipe lines larger than 4 in. inside diameter, and the entire fittings, valves and flanges on lines 4 in. and smaller, shall be painted distinguishing colors listed in the report.

Color symbols by themselves are not sufficient to overcome defacement by smoke, gases, dust and heat, and it is necessary for the color-blind to use something besides colors. Arrows should indicate the direction of flow, equalizing pipes and pipes with an alternating flow having double-headed arrows pointing in opposite directions, placed at distances to enable easy identification, not in excess of twenty feet, and located so as to be easily observed from the floor with permanently clear and distinctive colors, using 1-in. block letters and figures wherever possible.

The more simple a system is the less confusion and the more easily it will be remembered. The material conveyed by the piping may be designated by the initial letter—thus S for steam, S-hp. for high-pressure steam, etc.

Another good plan would be to paint only fittings and bands on the piping. Valve bodies may be stenciled R and L, indicating right- and left-hand valves and also may have substantial brass tags legibly stamped with number and letter in conformity with an adopted chart.

Toronto, Ont., Canada. T. W. REYNOLDS.

[1]Report of Committee on Identification of Power-House Piping. Also paper by William H. Bryan and discussion before the American Society of Mechanical Engineers' Detroit meeting, 1908.

Exhaust vs. Live Steam Heating

In the issue of Apr. 4, page 485, Mr. Underwood discusses the question of exhaust vs. live steam for heating and draws a conclusion that is opposite to the accepted theory. He states that radiation supplied with dry or superheated steam will give off more heat than radiation supplied with wet exhaust steam.

The various articles on the subject that have appeared during the past year or so seem to prove that the reverse is the case and as a further evidence of the soundness of the theory that a radiator with wet steam will radiate more heat than one with superheated steam at the same temperature, the following extract from Mr. McMillan's article on page 470 of the same issue is of interest.

> With superheated steam there seems to be at the inner surface of the pipe a sort of insulating film which allows the pipe to remain at a temperature considerably lower than that of the steam. Therefore radiation will be lower from pipes carrying superheated steam than from those carrying saturated steam at the same temperature.

Brooklyn, N. Y. W. L. DURAND.

Safety First for Power Plants

I was sorry to see the article by H. B. McDermid in the Mar. 14 issue because I believed the safety movement is of benefit to the workingman. Undoubtedly Mr. McDermid has cause for complaint in this individual case, but the safety movement itself is not to blame. Just because some unqualified man with a pull has succeeded in getting a soft job as inspector is no reason for condemning the movement as a whole.

The conclusion seems to have been drawn that because this company pays low wages the men are careless. I do not believe that low-priced men, as a class, are more careless than those better paid. They may, through ignorance, be more liable to injury than highly paid men, but I have seen some of the latter take big chances and seem to be proud of it. The ignorant man who does not understand his business is more or less afraid of his machine and is more careful as to what he does.

I have been connected with the safety movement for some time and am more or less acquainted with the four different types of inspectors.

Inspectors from the different trade associations investigate the plants of members and make recommendations. Whether or not they are complied with is up to the manager. They are high-grade, well-paid men, are courteous and perfectly willing to give reasons for their suggestions. They have made safety their profession, and I have always found their suggestions reasonable.

State inspectors are generally fairly well paid and, although sometimes subject to politics, seem willing to be reasonable and are glad to be shown why their recommendations should not be followed in specific cases.

Casualty-insurance inspectors, with whom it is a business proposition to reduce accidents, are high-grade men.

City or local inspectors are generally failures at other employments and are glad of a political pull to obtain an easy job at a wage about equal to a patrolman. These men as a rule are not only ignorant of their work, but are generally so swelled up with their own importance as to be a nuisance.

I could relate many amusing instances of this type and their demands. I presume likely it was one of this type that Mr. McDermid ran up against, and if so, he has my sympathy.

Our large corporations, such as railroads and steel mills, have demonstrated the value of the safety movement. The application of the movement in these large plants has in some reduced accidents as much as 75 per cent., and they have found it a paying proposition from the financial as well as the humane standpoint. Power plants as a rule do not employ enough men to demonstrate the value of the movement, but when other lines of industry find it of so much value, how can anyone question its worth in the power house? No one doubts the value of the boiler inspector, and yet he is certainly a member of the safety movement.

Let us not condemn a fine thing because of an individual mistake. These mistakes are the exceptions proving the rule. JOHN BAILEY.

Milwaukee, Wis.

An Odd Way To Fire

As in many other plants, we found that at times our grate surface was too large for the work to be done by the boiler. To correct this condition as far as possible, I instructed the fireman to throw on huge banks of coal, which is of the caking Kansas kind, one bank on each side of the furnace and one heavy bank down through the center of the grate, thus leaving two valleys, as it were, where the fuel bed might be kept thin and where by far the larger amount of combustion would take place.

We first tried wetting the coal that we banked, but found that the water caused the coal to crack, allowing air to go through and combustion to go on quite rapidly in the banks; dry coal corrected this condition.

Attica, Kansas. JOHN J. RAMSEY.

[Although Mr. Ramsey infers that this method was successful, it is certainly so poor on the face of it that we would not advise trying it, unless one wants to experiment just for experiment's sake.—Editor.]

Breakdown Service

Whether central-station breakdown service is the proper thing to install where no reserve units are provided is an open question. There are cases where it is better than putting in a spare unit, but the question cannot be answered for any given plant until all the conditions bearing on the subject are known. It depends on the cost of having the plant idle for a few hours; the cost of the breakdown service; the frequency with which these breakdowns are likely to occur, which, in turn, will depend on the condition of the machinery, its age and how well it is taken care of and the load; the cost and size of a suitable reserve unit; the size of the plant and the probability of whether an accident will put the entire plant out of commission or only a part of it; the nature of the work—whether material in the process of manufacture will be ruined, in which case interruption to service would be more expensive than under other conditions; and the reliability of the breakdown service available.

Breakdown service is the most expensive kind of central-station service. Aside from the charge made for the actual energy used, there is usually an additional

monthly charge depending on the service capacity installed. This is supposed to cover overhead charges on the reserve equipment installed in the central station; in other words, it is the "ready to serve" charge and goes on regardless of whether the service is used or not.

Where it is necessary to have uninterrupted service, it may be advantageous to have this outside service if the plant is small, but this brings up the question of just how large a plant would have to be to make the installation of an additional unit for reserve a paying proposition. That would also depend on the probable growth and nature of the business and whether the present plant is reasonably loaded at the time.

Where neither a reserve unit nor breakdown service is provided, there is a tendency on the part of many employers to insist on the engineer and his staff working overtime and on Sundays to make necessary repairs, and in some instances repairs that could be done during the week are deferred until Sunday so that the regular men can do the work without extra expense. This is a condition that is unfair to the engineers, and they are trying to overcome it by the installation of reserve units or outside service.

Another method of coping with the problem of interrupted service that can be applied to advantage sometimes is to have two or more isolated plants tied together.

The writer was employed in a plant where this idea was carried out. The electric light company had a load of street lights and commercial lights and power, and the other company had a block plant that supplied current for the block and also for several near-by blocks, besides some residence load. Neither plant had any reserve units, and they were owned by two separate interests. It was also necessary to provide uninterrupted service. Both plants generated 60-cycle 2,300-volt alternating current, and the block plant also had a direct-current system and rotary converters. An agreement was made that the two plants be tied together, a switch pilot lamp and wattmeter being provided at each end of the tie line. These switches were normally open, but if trouble arose in either plant the engineer would call up the engineer of the other plant and ask him to carry the load or as much of it as he could. The other engineer then stated the condition of his load and how much he could carry and closed the tie switch. The engineer having trouble then cut his load down, if necessary, to what the other plant could carry, and as soon as the pilot light showed that the other engineer was ready, he closed the switch at his end of the line and stopped his machine. This changing over was accomplished without dropping the motor load and without tying the two generators together except for an instant, as both oil switches were operated simultaneously. Neither plant had any reserve units, but those in service were not fully loaded and the plan worked out well. The success of this scheme, however, depends to a great extent on the compatibility of the engineers of the two plants.

These two plants used their ability to supply one another current not only during emergency, but also to give the men a little time off when the load was light, as on Sundays and holidays. This was arranged by the engineers of the two plants with the sanction of the employers. The only restriction was that the energy used by one company would be about the same as that sent through the line to the other company, so that the cost of the power bought by the one would about equal that sold to the other.

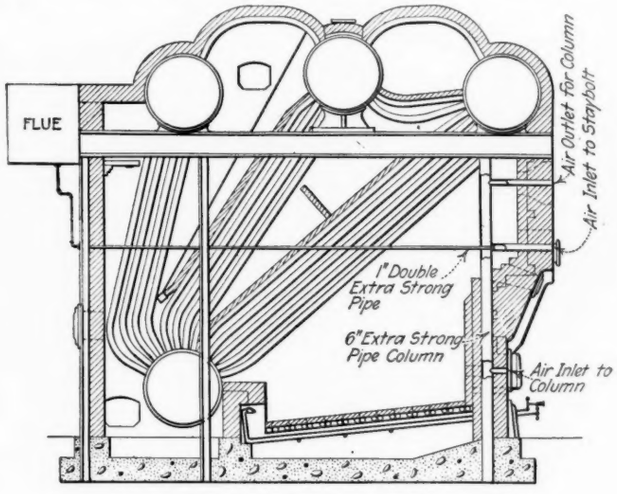
It seems to me that this plan might be worked out to advantage in many places. If the whole of both loads could not be carried by one plant, probably a part of the most necessary load could be handled, which would tend to eliminate the cost of reserve units or outside high-priced service.

J. C. HAWKINS.

Hyattsville, Md.

Ventilated Front Column in Oil-Burning Boiler

Inquiries have reached us recently about our method of repairing burned-out front columns and center-wall stay-bolts in Stirling boiler settings. It was found that with these boilers set in batteries of two and using "rear-shot" oil burners, the front column at the forward end of the center wall would become so hot that it would be badly distorted. The bending and buckling of the column had bulged the center wall on both sides.



HOW THE COLUMN WAS VENTILATED

These front columns are made up of two structural-steel angle bars riveted together with distance pieces, leaving sufficient room between them for the stay-bolt to pass through. It was also found that the center stay-bolt was burned off for a distance of 3 ft. opposite the center of the firebox. We first attempted to remedy this by covering the front column and stay-bolt with a thick layer of asbestos pipe covering, but found that this was no protection as the columns were destroyed just as rapidly as before.

We then put in a front column made of extra-heavy 6-in. pipe ventilated as shown. Cold air is drawn in through a 3¼-in. hole near the lower end of the column and passes up and out at the 3¼-in. hole near the top. Short pieces of boiler tubes were used as inlet and outlet pipes; these were beaded over at their outer ends where they come through ironwork. For the stay-bolt, which was 1⅛-in. diameter, we used double-extra-heavy 1-in. pipe with 1⅜-in. machine threads, and at the rear end tapped inside of the pipe for ⅜-in. pipe threads. A ⅜-in. pipe connection was carried from here through the bottom of the smoke flue, as shown. A ⅜-in. elbow

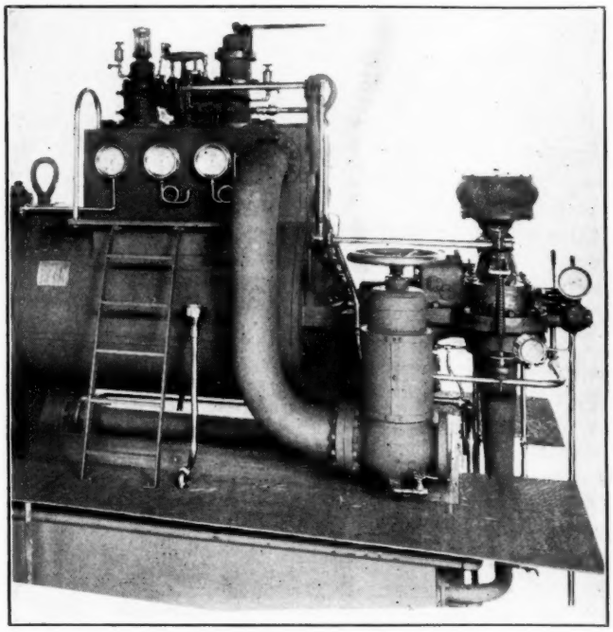
is put on inside of the flue 3 in. from the floor to prevent soot from dropping into the ⅜-in. pipe. The flue draft draws cool air through the hollow stay-bolt and keeps it from becoming hot enough to be damaged.

This method is satisfactory in every way, as there have been no burned-off stay-bolts or front columns since its application.

C. V. WALKER,
Asst. Chief, Southern California Edison Co.'s Station.
Long Beach, Calif.

Turbine Oil Pump Fails

A rather unusual turbine accident was brought about by the breaking of the connecting coupling of the oil pump close to the pump gears on our turbine. The fracture was thought to have been caused by a tooth of



1,000-KW. TURBINE, SHOWING OIL COOLER, OIL PIPES, GOVERNOR AND VALVES

one of the pump gears breaking owing to crystallization, then wedging itself between the gears. Another explanation was that perhaps something in the oil caught in the rotary pump, which has limited clearance, causing the gears first to break and later to wedge, breaking the shaft. Whatever the original cause, the gears were found to be in bad condition. At least half of the teeth were broken, while the impeller of the pump showed no signs of wear and tear.

The gears and impeller in this style of pump are in separate compartments, so that the pieces from the gears could not do any damage to the impellers, nor could the chips and pieces of the broken gears get into the oil system or the bearings. With the stopping of the oil pump and the consequent decrease of pressure on the relay oil system, the turbine did not stop of its own accord, as one would at first suppose, owing to the intake valve being held open by the pressure of the relay oil, but continued to take steam. This was evidently because the governor was not moving at that time, and so the piston valve, which admits and exhausts oil from either side of the oil cylinder that operates the intake valve, was in a central position, holding the valve open. If the governor had moved either way, it would have moved the piston valve, released the oil and closed the valve, shutting off the steam.

The babbitt on the outboard bearing of the generator let the rotor down so that its shaft was rubbing on the housing. The operator immediately took the machine off the line, tripped the stop and started the auxiliary oil pump. Notwithstanding the quickness with which he acted, the babbitt in all four bearings had run, the governor bushings were burned to the shaft, the cross-shaft bushings and cross-shaft badly cut, and the worm and worm gear so badly cut that they had to be replaced.

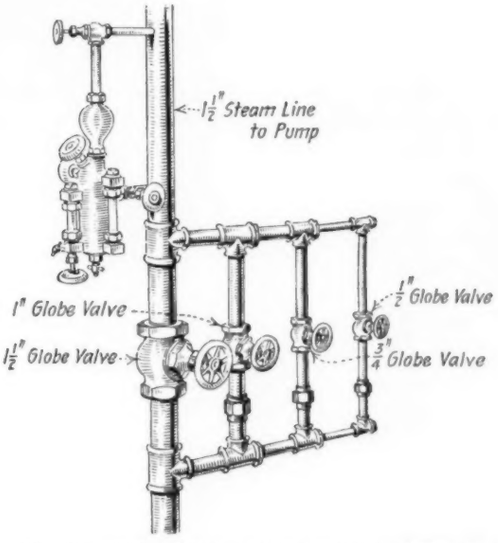
The spindle did not come down far enough to damage the blading, although the ends of some were bright where they had started to rub. Excellent coöperation on the part of the builders and ourselves enabled us to have the machine back on the line in 82 hr. The machine is shown herewith.

The breakdown was unusual, as the makers state that they have had only one case like it and therefore do not consider that automatic devices to start the other pump as soon as the pressure drops are necessary.

Clinton, Iowa. R. E. CLINBECK.

Home-Made Pump-Speed Regulator

The accompanying sketch is of a home-made pump-speed regulator working on a 9&5¼x12-in. boiler-feed pump. It did away with an $80 pump regulator and also



PIPING FOR REGULATING STEAM SUPPLY

the trouble of cut valve seats and disks where one size of throttle valve is used and cracked to regulate the flow of steam. The pump speed required can be maintained with whatever valve is used wide open or opened at least enough to overcome the cutting. If one open valve is not enough to maintain the pump speed, a larger one is opened.

This throttling outfit has been in use every day for six months. It has shown no leakage, nor have the valve disks been renewed.

JOHN J. BREWER.
Ray Brook, N. Y.

Centrifugal Effect in Belting

Enough is not yet known about the relation between the slack belt and centrifugal tension. Manufacturers advise operatives to run belts slack because, with proper care, they pull very well indeed, without slip; yet the centrifugal-tension bugaboo continues to be thrust forward as though it were worthy of consideration. Centrifugal effects exist, true enough. There can be no doubt about it. I have seen a photograph of an india-rubber belt moving at a high speed, as indicated in Fig. 1, where the lower pulley was not even touched by the belt and was at a standstill, while the belt kept running. That, however, was a vertical belt, and it was not slack. Had it been horizontal and slack, I am of the opinion that it would have behaved just like a regular horizontal slack-belt drive as shown in Fig. 2. Now my arguments in favor of the slack belt are these:

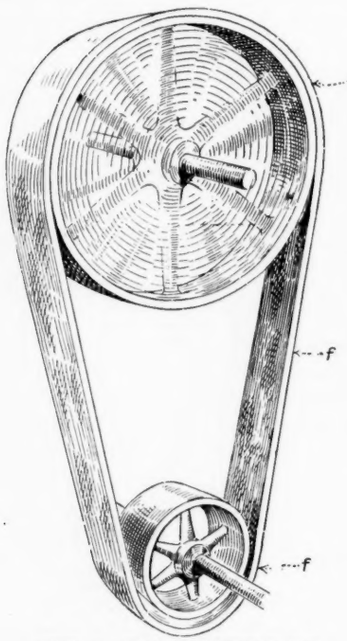


FIG. 1. ELASTIC BELT AT HIGH SPEED

According to the formula centrifugal force f depends entirely upon velocity in a curved path. Hence, does it not seem reasonable to claim that in Fig. 2 all of the ill effects due to centrifugal tension are counterbalanced? Since the belt is running at the same speed all over, it is impossible for variation to exist in any part. The formula therefore shows that the centrifugal tension in the portion of the belt traveling around pulley A is exactly the same as the centrifugal tension in the portion of the

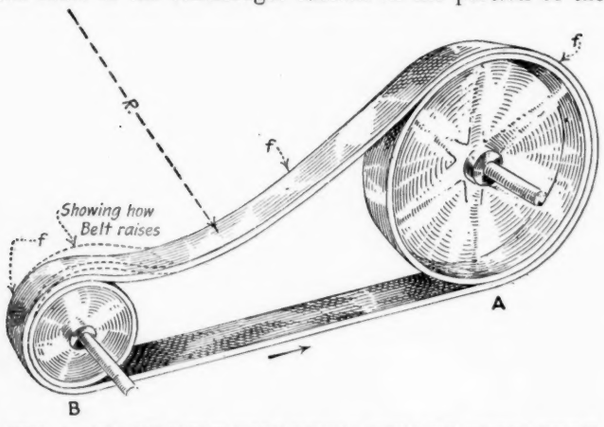


FIG. 2. SLACK BELT FOLLOWING PULLEY CURVATURE

belt traveling around pulley B, and between the pulleys we have the slack side of the belt traveling around the center in the air with radius R. The centrifugal tension there, according to the formula, should exactly counterbalance the other two, and I can see no reason why there should be any tendency for the belt to "fly off the pulleys."

Personally I have never had any trouble with centrifugal tension, and I have run belts at pretty high speeds; but I am told by experienced belt men that when a high-speed belt approaches the small pulley it has a tendency to lift up and follow the dotted line, over pulley B.

Perhaps this lifting occurs where the belt is not slack enough. If the horizontal belt is tight, it will very likely want to follow the tactics exhibited in Fig. 1. Where there is plenty of slack, however, and where there are no "waves" in the belt, the formula plainly shows that centrifugal tensions are counterbalanced.

The only harmful effect centrifugal tension can have in a slack belt, then, is the reduction of useful pulling strength. I have figured that where lapped and riveted belts run at a speed of two miles per minute, the useful pulling strength is all gone. The belt is liable to burst at any moment, owing to centrifugal tension alone.

New York City. S. F. Wilson.

Salary Out of Proportion

On June 1, 1914, I assumed the duties of chief engineer at a United States Indian School in the West—this was my fourteenth year as an engineer in the United States Civil Service. The plant consists of two Scotch marine boilers rated at 150 hp. each, one of them to be in service at all times. I found scale in them from ½ to ¾ in. thick—in some places solid between the flues, so that it had to be chipped out with a hammer and chisel.

I found one branch of the exhaust line connected to the condenser and the other to a 500-hp. feed-water heater, with no way to shut off the condenser and no way to use the exhaust when we did not need the condensed steam for making ice. The heating system was not connected so as to use the exhaust steam.

I shall not try to describe the so-called hot-water heating system except to say that the hot water left the power house in a 4-in. pipe, went to the first building and was supposed to heat it and then go back into the same pipe and heat the next building, and so on around the grounds. The designer deserves a leather medal. The water was partly heated by the exhaust steam. A reducing valve, intended to pass live steam into the exhaust, was fixed so that the weight held the valve closed instead of open. I was told that this valve never did work and am not surprised that it did not.

The steam trap to handle the condensate from a large mangle in the laundry was connected up backward, and the bleeder had to be kept open all of the time and the water allowed to run across the floor into the sewer. Another trap was completely filled with scale and dirt, and the only way to get action was to open the bypass and blow the water out on the ground. All the cooking for the six or seven hundred Indians is done by steam, and the trap under the kitchen was full of dirt and scale and the bypass was used.

The cost of fuel oil for the power house for the fiscal year from July 1, 1913, to July 1, 1914, was $3,600, but for the year following (to July 1, 1915) it was only $2,365.84, making a saving of $1,234.16; also the total bill for electricity was $338.11 less than it was the previous year, making a net saving in my department of $1,572.27, which was $272.27 more than my salary during the same period. R. A. Perry.

Phoenix, Ariz.

Inquiries of General Interest

Regulation of Oil Burners—In burning oil for generation of steam by the use of steam-spray burners, how can it be known how to regulate the supply of oil and steam to the best advantage? M. H.

When the burner valves and the air supply are correctly adjusted, the flame is a bright white and there is no smoke. When starting, the oil should first be turned on and ignited and then the steam should be turned on. The valves controlling the oil and steam can best be regulated for obtaining the proper mixture by observing the top of the smoke-stack and the color of the fire. If there is too much steam, it will be seen surrounding the burning spray and issuing from the smoke-stack; if the steam supply is too small, there will be imperfect atomization that will be indicated by scintillating sparks. If the air supply is too small in proportion, the color of the flame will become red and smoke will issue from the stack.

Equivalent Evaporation—How many pounds of water would have to be evaporated from feed water at a temperature of 210 deg. F. into dry saturated steam at 145 lb. per sq.in. gage pressure to be equivalent to the evaporation of 34.5 lb. of water from and at 212 deg. F.? R. B.

Each pound of the feed water at 210 deg. F. would contain 210 — 32 = 178 B.t.u. above 32 deg. F., and as a pound of dry saturated steam at 145 lb. gage, or about 160 lb. absolute, contains 1,194.5 B.t.u. above 32 deg. F., each pound of the feed water converted into steam under the conditions stated would require 1,194.5 — 178 = 1,016.5 B.t.u. The heat required for the evaporation of a pound of water from and at 212 deg. F., or the latent heat of evaporation at atmospheric pressure, is 970.4 B.t.u., and under the conditions stated, each pound of the feed water would require 1,016.5 ÷ 970.4, or 1.0475, times as much heat as if evaporated from and at 212 deg. F.; and therefore the evaporation of 34.5 ÷ 1.0475, or 32.93 lb. of water, would be equivalent to the evaporation of 34.5 lb. of water from and at 212 deg. F.

Thickness Required for Dished Head—What thickness would be required for an unstayed bumped head with a working pressure of 190 lb. per sq.in. on the concave side if the head is dished to a radius of 42 in., when made of steel plate of 60,000 lb. tensile strength? G. S.

The formula of the A. S. M. E. Boiler Code for thickness of unstayed dished heads with the pressure on the concave side, when the head is a segment of a sphere, is

$$t = \frac{5.5 \times P \times L}{2 \times TS} + \frac{1}{8}$$

where

t = Thickness of plate, in.;
P = Maximum allowable working pressure, lb. per sq.in.;
TS = Tensile strength, lb. per sq.in.;
L = Radius to which the head is dished, in.

Substituting the values given in the question the formula becomes

$$t = \frac{5.5 \times 190 \times 42}{2 \times 60{,}000} + \frac{1}{8} = 0.49075 \text{ in.}$$

or practically the thickness of the plate should be ½ in.

To Measure Angle of Advance of Eccentric—How can the number of degrees of angular advance of an engine eccentric be measured? G. R.

When there is an outside admission valve and the valve gear has no rocker for moving the valve in a direction reverse to the motion of the eccentric rod, the angular advance of the eccentric will be the number of degrees it is more than 90 deg. ahead of the crank. To find the number of degrees of advance, turn the engine forward and mark the periphery of the wheel with reference to a stationary object when the eccentric rod or valve stem is in the middle of its travel, and moving the engine forward make a similar mark on the wheel with reference to the same stationary object when the crank arrives on the center. The distance between the two marks measured circumferentially on the wheel will be the angle of advance laid off on the periphery of the wheel. This distance multiplied by 360 and divided by the wheel circumference on which the distance was measured will give the number of degrees of angular advance of the eccentric.

When there is an outside admission valve and a rocker that moves the valve in a reverse direction to the motion of the eccentric rod, the angular advance will be the number of degrees the eccentric is less than 90 deg. behind the crank. To measure this, first place the crank on either center, and after marking the periphery of the wheeel with reference to a stationary object, turn the engine forward until the eccentric rod or valve stem is in the middle of its travel, and make a similar mark on the periphery of the wheel with reference to the same stationary object. The distance between the two marks measured circumferentially on the wheel will be the angle that the eccentric is behind the crank, and this distance multiplied by 360, divided by the wheel circumference and subtracted from 90 will be the angle of advance in degrees.

When there is an inside admission valve and no reversing rocker, the angle of advance is found the same as with an outside admission valve and a reversing rocker, and vice versa.

Measuring for Length of Connecting-Rod—How would the measurement be taken for the length of a new engine connecting-rod without referring to the old rod? K. S.

The length of the connecting-rod is designated by the distance from the center of the crosshead pin to the center of the crankpin and should be such that the clearance will be the same between the piston and the end of the cylinder at each end of the stroke. To find the distance between centers that will fulfill this condition, disconnect the old rod, move the crosshead, piston and piston rod until the piston is

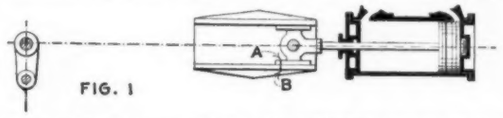


FIG. 1

brought up against one end of the cylinder, as in Fig. 1, and make a mark A on the crosshead corresponding with a mark B made on the guide. Then move the crosshead, piston rod and piston in the opposite direction until the piston strikes

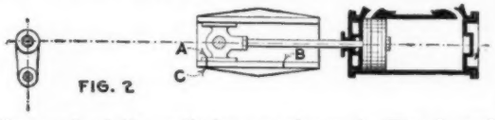


FIG. 2

the other end of the cylinder, as shown in Fig. 2, and make another mark C on the guide corresponding with the mark previously made on the crosshead.

Next locate a third mark D on the guide midway between the first and second marks on the guide and move the crosshead and piston to such a position that the mark A made on

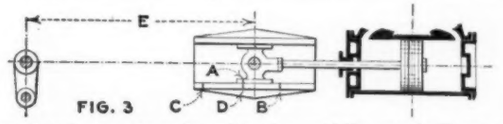


FIG. 3

the crosshead corresponds with the middle mark D as shown in Fig. 3. With the crosshead in this position the proper length for the connecting-rod can be found by taking the distance E from the center of the crosshead pin to the center of the shaft. Or if it is more convenient to measure from the crosshead pin to the crankpin, move the crosshead to either side of the middle mark D on the guide a distance R equal

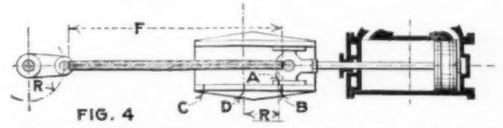


FIG. 4

to the radius of the crank, as shown in Fig. 4, and with the crank on the center corresponding to the position of the crosshead, obtain the distance F with a gage stick whose length end to end will be the distance from the crosshead pin to the crankpin. This distance plus one-half the diameter of each pin will be the center-to-center length required for the connecting-rod.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.

American Society of Mechanical Engineers' Boiler Code*

By S. F. Jeter†

It is no longer a question of whether we shall have laws on the subject of boiler design, construction and operation, but rather what these laws shall be.

With the wave of "Safety First" that has swept the country and the consequent demand for legislation on the subject of boiler construction and operation, it behooves the steam user to see that his interests are not overlooked. It is not meant by this that opposition should be made to any sane legislation on this subject, for the steam user should not and will not be opposed to any necessary regulation for safety in regard to either the operation or construction of boilers.

The boiler user, from a financial standpoint, is mainly concerned in seeing that his competitors do not enjoy immunity from regulation with which he must comply, and the average user would not consider it a particular hardship if he were compelled to adopt measures the benefits of which might be debatable, provided his competitors were compelled to follow the same rules.

Why is a steam user vitally interested in having one set of rules govern the construction of all boilers?

The consumer pays the extra cost of the product manufactured under adverse conditions. While it may not be of vital importance to the user of a boiler whether the stays are to be spaced 6 in. or 6¼ in. apart, whether the steel of which the shell is constructed is to have a maximum tensile strength of 60,000 or 65,000 lb. per sq.in., or whether it must be of the flange or firebox grade, it is necessary for the boiler manufacturer, in order to produce this boiler economically, to know beforehand the kind of stock he should order and the rules that must be followed in the construction of the boiler in order that he may purchase in quantities and handle his product through the shop in an economical manner. In order that he may do this, he should be required to build boilers to only one standard code and not be obliged to meet varying requirements in every different state or city. Even with the limited number of laws now in force, it is difficult to design and manufacture a boiler to meet the requirements of the rules of the several states, and unless uniform rules are adopted, the boiler user is the one who will feel the result of added cost without compensating benefit.

A NATIONAL COMMISSION NOT PRACTICABLE

Since the requirements governing safety in the construction of boilers must be uniform to be logical and to secure the greatest return to the boiler purchaser, it follows that they should emanate from the same source. If it were not for interference with states' rights, it would appear that the appointment of a commission by the National Government would be the way to decide the matter, but a commission appointed for such purpose would naturally be given authority to decide positively all questions without regard to the complaints of those who might be affected by their rulings, and the result might not be as expected or desired.

If each state acts independently in the matter, there can of course be no uniformity in the rules, and none of the rules thus drafted can possibly be the best, for they would not represent the combined wisdom of the different boards drafting them.

The American Society of Mechanical Engineers, in 1911, recognizing the chaotic condition that was fast being approached by the adoption by the separate states of rules governing the construction of boilers, appointed a committee to draft a set of such rules that might be used by the various states as a guide in the making of rules to govern boiler construction when adopting boiler laws. The original committee of six members was augmented to four times that number by the appointment of an advisory committee. This committee distributed upward of two thousand printed copies of the tentative code, and invited the coöperation and discussion not only of every engineer who had special knowledge upon the subject, but of all the interests affected, and only after innumerable discussions and hearings was the code in its present form approved by the foremost engineering society of this country, so far as that society ever approves a document of this character.

The code thus produced is by no means beyond criticism, and no set of rules for a similar purpose may be drafted without being open to criticism at some points; but it is safe to say that this boiler code is the most complete and logical set of rules governing the construction of steam boilers in existence today, and is advocated and backed by practically every interest connected with the manufacture and use of steam boilers. Its staunchest supporters are those most directly affected by its requirements, and the benefits to be gained by such supporters through its adoption are largely of an indirect character. The boiler manufacturers who were actively engaged in the work of compiling the boiler code were without doubt the ones who received the least consideration in regard to the possible effect of the code provisions on their standard designs or methods of construction. The code is free from any attempt to favor any particular type or design of boiler or particular method of construction. It has no effect or influence on boiler design, except in regard to safety, and as long as the designer keeps within prescribed limits for stresses and uses materials that practice has demonstrated as really reliable for the purpose, his inventive genius will not be hampered in the least.

The boiler code does not attempt to influence the size or pressure required for a boiler intended to met the particular needs of a steam user, and the advice of your engineer in determining such questions is as much in demand as ever; but instead of being occupied in looking after details of boiler design connected with safety, your engineer will be free to make a more careful study of the possibilities in regard to economical operation, and it is in this direction that you really expect to receive returns from expenditure made in retaining a consulting engineer.

A. S. M. E. CODE BEST SET OF RULES AVAILABLE

If the need for adopting the same set of rules in each state where laws are proposed to govern the construction of boilers is admitted—and it does not seem possible that the least thought on the subject can lead to any other conclusion from the steam users' standpoint—then the American Society of Mechanical Engineers' Boiler Code is practically the only set of rules available for such use. All disputed points in connection with these rules have been fought out with the parties interested, and a conclusion reached; and any attempt at selecting a different set of rules would mean that the same ground would have to be fought over again, with the probable arrival at the same conclusion if a like amount of careful consideration was given to it.

This code has already had the approval of many of the largest steam users in the country, and it is surprising to find the number who are today ordering their new boiler equipment built in accordance with its requirements, when the short length of time that this code has been in existence is considered. The boiler manufacturers throughout the country have adopted the code through their different organizations, and the boiler-insurance interests are unanimous in their approval of its provisions.

It should be thoroughly understood that the boiler code is purely a code of rules by which the construction of new boilers may be governed and the safe maximum allowable working pressure for both old and new fixed, and that it has absolutely nothing to do with the law that is required to compel compliance with its provisions. There is nothing in the boiler code to prevent its use as an alternative for rules already used in a state, and that such an arrangement is entirely practical is evidenced by its use in this manner by such states as Ohio, Wisconsin and Indiana, and by the City of Detroit, all of which will accept boilers built under code requirements in lieu of the construction called for by their own particular rules.

SEVERAL STATES ADOPT A. S. M. E. CODE

On July 1 of this year the State of Pennsylvania will require that all boilers used in that state, and which are not under municipal law, comply with the provisions of the American Society of Mechanical Engineers' Boiler Code, and the State of California will take the same step the first of the coming year; in fact, every state in the Union that has a state boiler law, with the single exception of the Commonwealth of Massachusetts has either adopted the American Society of Mechanical Engineers' Boiler Code or will accept boilers built under its provisions in lieu of their own requirements.

The brunt of the fight for uniform rules to govern boiler construction has been carried on thus far by the boiler manufacturer, but since the steam user is the one who will ultimately derive the greatest benefit from the attainment of the desired end, in that he will secure the greatest return for his investment in boiler equipment, it would seem only right that, as the project has been so auspiciously launched, the steam users, through such associations as the National Association of Cotton Manufacturers, should lend their full co-

*Abstract of paper presented at the annual meeting of the National Association of Cotton Manufacturers, Boston, Mass., Apr. 27.

†Chief Engineer, Hartford Steam Boiler Inspection and Insurance Co.

operation in carrying the work to a complete and successful finish. The question is not whether the steam user shall seek the enactment of boiler laws, but when such laws are thrust upon him, whether he shall demand that a known set of rules governing boiler construction be used, or be content to sit still and take whatever rules happen to be furnished. Will you feel safe to have the construction of boilers you may purchase governed by a code put out by the foremost engineering society of the country, and like that which will be used by a majority of your competitors and purchased under as favorable conditions, or do you desire special frills that may be demanded by local rules at a considerable advance in price over the standard product?

Humidity and Its Measurement

By Kenneth G. Smith*

According to the Law of Partial Pressures, commonly known as Dalton's Law, two gases at the same temperature do not interfere with each other's pressures when mixed, provided there is no chemical action. Each one exerts the same pressure that it would at the given temperature if the other were not present. The total pressure is the sum of the pressures of the two gases. Experiment shows that this law holds good for a mixture of gas and vapor such as water vapor and air. Taking water vapor and air as an example, if P_a is the air pressure and Po the vapor pressure, then $P_a + P_o = P_t$ = total pressure of vapor and air. If the vapor is saturated, the temperature of the mixture is definitely fixed at the saturation temperature corresponding to the pressure P_t. If the temperature is higher than the saturation temperature at the given pressure, the vapor is superheated. Water vapor in the atmosphere is superheated except on damp, foggy days, when the water vapor is saturated, or as we say, the air is saturated with moisture.

The weight of a cubic foot of superheated vapor is less than the weight of a cubic foot of saturated vapor. If m_1 is the weight of a cubic foot of saturated vapor and m_2 = weight of a cubic foot of superheated vapor at the same temperature, then the ratio $\frac{m_2}{m_1}$ expressed in per cent. is called the humidity of the air containing the vapor. That is, it is the ratio of the moisture actually contained in the air to that which the air could contain at that temperature if saturated.

If a mixture of air and superheated vapor is cooled at constant pressure (say atmospheric pressure), it will finally reach a point where the vapor becomes saturated instead of superheated and further cooling results in condensation. The temperature at which condensation begins is called the dew point. This is simply the saturation temperature for the given pressure. The gas law PV = constant, which we may assume holds good for low vapor pressures, gives us the means of calculating the ratio $\frac{m_2}{m_1}$ already referred to as the humidity.

Let P_1V_1 represent the condition of saturated vapor at the given temperature and P_2V_2 its actual condition at this temperature—that is, in its superheated state. Then

$$P_2V_2 = P_1V_1 \text{ and } \frac{P_2}{P_1} = \frac{V_1}{V_2}$$

If the vapor is cooled at a constant pressure P_2 down to the saturation temperature—that is, to the dew point—then since P_2 is unchanged the ratio $\frac{P_2}{P_1} = \frac{V_1}{V_2}$ still holds good; now substituting for the volumes per cubic foot, their reciprocals, the weights per cubic foot, $\frac{P_2}{P_1} = \frac{m_2}{m_1}$.

Hence, the humidity in per cent. is equal to the ratio of the pressure corresponding to the dew point to the saturation pressure corresponding to the temperature of the mixture. An example will make this method of measuring humidity clear. Suppose that air has a temperature of 70 deg. and the dew point is found to be 50 deg. What are the humidity and weight of vapor per cubic foot? From a table of vapor pressure we find that at 55 deg. the saturation pressure is 0.436 in. of mercury. At 75 deg. the saturation pressure is 0.8735 in. of mercury. The humidity is then $\frac{0.436}{0.8735} = 50$ per cent, very nearly. If the air were saturated at 75 deg., it would contain 9.36 grains of moisture per cubic foot. Hence, at 50-per cent. saturation it contains $9.36 \times 0.5 = 4.68$ grains per cubic foot.

To measure moisture in this way would be difficult under other than laboratory conditions, and for that reason another method, using a wet- and a dry-bulb thermometer, has been adopted. The dry-bulb thermometer is simply an ordinary Fahrenheit thermometer. The wet-bulb instrument is exactly the same except that it has a piece of muslin or other porous material wrapped around the bulb and saturated with water. When both are exposed to the air, the wet-bulb thermometer immediately falls to a lower temperature than the other, owing to the fact that the evaporation of the moisture in the cloth requires heat. The drier the air the more the evaporation and the greater the drop in temperature. From the difference in temperature between the wet- and dry-bulb thermometers the humidity may be calculated. In practice it is not calculated, but read directly from a table or curve.[1]

One might naturally ask the reason for the fixed temperature to which the wet-bulb thermometer drops. This temperature is known as the temperature of adiabatic saturation and is fixed for any dry-bulb temperature and percentage of humidity. To understand this statement, imagine three thermometers placed in a body of air to which moisture is to be added without exchange of heat with any source outside of the air and water. The first thermometer is arranged to show the dew point and reads the lowest. The second, or dry-bulb, thermometer shows the dry-bulb temperature or, as we call it, the temperature of the air. The third thermometer shows a temperature between the dry-bulb temperature and the dew point. To make the case concrete, take, for example, air at 70 deg. and 33 per cent. saturated. Then the conditions are as follows: Dry-bulb temperature, 70 deg.; dew point, 39 deg.; wet-bulb temperature, 54 deg.

If now a fine spray of water having a temperature higher than 39 deg. is introduced, the air absorbs moisture with the result that the dry-bulb temperature drops at once, the dew-point temperature rises and the wet-bulb temperature remains stationary. The reason is that the total heat of the air is constant. The heat required to evaporate the moisture is rendered latent, and the sensible heat as shown by the dry bulb thermometer becomes less, but the sum of latent and sensible heat is constant. If moisture continues to be added, the dew-point temperature continues to rise, the dry-bulb temperature continues to fall until all three are stationary at the wet-bulb temperature, when the air is saturated. The total heat of the air is the same as it was before the moisture was added, but it contains more latent and less sensible heat. On the total heat the wet-bulb temperature depends, and therefore it is fixed for any temperature and percentage of humidity, because the total heat of the air in the given condition is fixed.

In the example given the percentage of humidity may be calculated if we know the dry- and wet-bulb temperatures. These are as given, dry-bulb 70 deg., wet-bulb 54 deg. The temperature of adiabatic saturation is 54 deg., and at this temperature the air contains 62.14 grains per pound when saturated. The total heat of the mixture equals the heat of the air plus the heat of the moisture, or

$$0.2375 \times 54 + \frac{1,084.7 \times 62.14}{7,000} = 22.44 \text{ B.t.u.}$$

Since the total heat of the air is constant during the change, the total heat at 70 deg. equals the total heat at 54 deg., or

$$0.2375 \times 70 + (1,084.7) + 0.48 \times 16 \times X = 22.44$$

X = Grains of moisture in air at 70 deg.

0.48 = Specific heat of the vapor.

Solving for X, we have X = 37.2 grains per pound of air.

Since saturated air at 70 deg. contains 110.01 grains per pound, the humidity is $\frac{37.2}{110.01} = 33$ per cent.

The Increasing Influence of the Engineer*

A society such as this, which is composed of engineers in many special branches, is doubtless of more value to the individual members than some of the other more closely drawn technical societies and institutes. Further than this, most of the men seated around this board tonight are the active, hustling members of the profession who are engaged in directing both men and the forces of the world to produce some organization, some plant or some installation that shall not only render a service to some of our fellow-men, but shall operate both economically and profitably for the individual or corporation for which the work is done.

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*Professor engineering extension, Iowa State College, in the "Iowa Engineer."

[1] A psychrometric chart for this purpose was printed in "Power," Mar. 28, 1916, page 435.

*From an address prepared for the New England Association of Commercial Engineers, Revere House, Boston, Mass., Mar. 18, 1916, by John J. Hines, consulting engineer. Halifax, N. S

As I grow older, it becomes impressed on me more and more that the engineer is becoming a greater factor in civilization every day. It is upon him that our social and industrial life depends more than on any other individual. It is he who has constructed our railroads, built and driven our ships, laid our cables, erected our factories, reclaimed our waste places, spanned our rivers, built our highways, constructed our telegraph and telephone lines, separated our continents to provide short water routes for navigation and performed the many mighty tasks that have advanced civilization more in the last one hundred years than it advanced in the previous twenty centuries.

Up to the present the men who have made our laws and directed the destinies of nations have been for the most part lawyers, glib-tongued politicians or wealthy aristocrats. The time is coming shortly when the engineer will sit in the councils of state and exert his influence in the efficient and economical organization of society that sane and progressive thinkers are demanding of national governments. In the recent progress toward municipal administration by a single city manager, the men who have been given the concentrated power in the places that have adopted this plan have almost invariably been engineers. This should be a great source of satisfaction to us, but we should realize our growing responsibilities and try to make ourselves as thoroughly wise and efficient as possible.

Some people have placed the pure scientist, who works only for the love of science, above the practical engineer, who works for profit and who is engaged in installing machinery, plants, etc., for others to operate for a profit. This is not as it should be. One should be regarded for the service which he renders to others, for the forces which he controls and directs for the good of mankind. If the scientist will not bend his energies to develop anything of immediate utility, he should not be placed in the social scale above the engineer that turns a stream into a desert land or the one that installs a ventilation system in a school that the pupils may always have the proper amount of fresh air. The engineer is entitled to all that he can make by rendering the forces of nature in some way serviceable to mankind.

Commercial Lighting*

Commercial lighting embraces the lighting of stores, factories, churches, halls and other places of a public or semi-public nature. It is in this field, since the introducton of electric lighting, that gas has met the most severe competition. In efficiency which leads to economy, gas has always successfully met electric competition, but the advantage of economy in operating costs, formerly so beneficial to the gas industry, does not exist to the same extent today.

In considering the comparative costs of illumination by gas and electricity, there must be taken into account the cost of gas or of electric energy, the efficiency of the units used and the cost of their upkeep. A few years ago the average medium-sized store could be illuminated by three upright gas lamps at a cost of $76 per year, including gas and maintenance. The cost to illuminate such a store by electricity with carbon lamps was about $385. The inverted gas arc lamp made it possible to light a similar store for $55, compared with $95 using tungsten lamps. Today, with the most efficient units available, the cost would be $51 for gas and $60 for electricity.

In these comparisons gas is figured at $1 per 1,000 cu.ft., and electricity at 10c. per kw.-hr.; and, while it is true many companies are selling gas much lower than $1 per 1,000, it must be recognized that electric companies have largely adopted the demand system of charging for current, and though the base rate for a few hours' burning may be 10c. per kw.-hr., the excess after one hour's average daily burning is secured at a much lower rate. For the average commercial installation this would mean that the low rate would be secured for the current used in excess of $3 per month, and in many instances much less than this amount. The newer lamps, with their lessened demand, will result in a still lower amount to which the base rate will be applicable. However, the costs of illumination with gas and electricity have been decreased principally by the increased efficiency of the lamps. Today 32 cp. is secured with 1 cu.ft. of gas, as compared with 17 cp. a few years ago. The increase in efficiency of the electric units has even exceeded that of the gas units, and it is now possible to secure 13 cp. with a consumption of 10 watts, where a few years ago it was necessary to use 10 watts for 3 cp. These figures show that the advantage of low operating costs for gas has decreased materially.

*Excerpt in "Journal of the Franklin Institute," of an article by E. M. Colquhoun, in "American Gas Light Journal."

Air-Lift Pumps and Compressor Capacities

The formula commonly employed in obtaining the size of air compressor for an air lift is

$$\text{Free air in cu.ft. per min.} = \frac{\text{gal. of water delivered per min.} \times \text{lift}}{125}$$

In some cases this formula serves admirably; but, since it takes no account of the depth of submersion, its general application is fraught with no little danger to the designer's reputation.

The over-all efficiency,

$$\frac{\text{Work done in lifting water}}{\text{Indicated work in engine cylinder}}$$

lies generally between 25- and 45-per cent. limits, which are too wide to permit of any efficiency guarantee being given with a particular plant. With a well-proportioned pump the minimum over-all efficiency ought to be 30 per cent. Allowing 75 per cent. for the compressor efficiency, then the work done in lifting the water should be about 40 per cent. of the indicated work in the cylinder of the compressor.

The following formula takes the submergence into account and is therefore of much wider application. Let

Lift = L ft. (measured from surface of the water while pumping to delivery outlet);

Submergence = S ft. (in good plants S is about 2 L);

V_a cu.ft. = Volume of free air used per second;

P_a lb. per sq.ft. = Atmospheric pressure, equivalent to 34 ft. of water;

P_1 lb. per sq.ft. = Pressure at foot of rising main;

V_w cu.ft. = Volume of water raised per second.

Then

$$\frac{P_1 - P_a}{P_a} = \frac{S}{34} \qquad \text{Therefore } \frac{P_1}{P_a} = \frac{S}{34} + 1$$

Now, assuming isothermal compression, the work done on the air by the compressor per second

$$= P_a V_a \log_e \frac{P_1}{P_a} \text{ ft.-lb.}$$

$$= 2.3\, P_a V_a \log_{10} \frac{P_1}{P_a} \text{ ft.-lb.}$$

$$= 2.3 \times 14.7 \times 144 V_a \log_{10} \frac{P_1}{P_a} \text{ ft.-lb.}$$

$$= 4{,}869\, V_a \log_{10} \frac{P_1}{P_a} \text{ ft.-lb.}$$

Then work done in lifting V_w cu.ft. of water through a lift of L ft.

$$= 62.4 V_w \times L \text{ ft.-lb.}$$

$$\text{Therefore efficiency} = \frac{\text{work done in lifting water}}{\text{indicated work in compressor}}$$

$$= \frac{62.4 V_w \times L}{4{,}869\, V_a \log_{10} \frac{P_1}{P_a}}$$

$$= \text{say, } \eta$$

$$\text{Therefore } V_a = \frac{62.4 V_w \times L}{4{,}869 \times \eta \times \log_{10}\left(\frac{S}{34} + 1\right)}$$

Therefore. Free air in cu.ft. per min.

$$= V_a \times 60$$

$$= \frac{62.4 \times \text{cu ft. of water per min.} \times L}{4{,}869 \times \eta \times \log_{10}\left(\frac{S}{34} + 1\right)}$$

$$= \frac{10 \times \text{gal. of water per min.} \times \text{lift}}{4.869 \times \eta \times \log_{10}\left(\frac{S}{34} + 1\right)}$$

$$= \frac{\text{gal. of water per min.} \times \text{lift}}{487 \times \eta \times \log_{10}\left(\frac{S}{34} + 1\right)}$$

Assuming $\eta = 0.4$, or 40 per cent,, then the following simple formula is obtained:

$$\text{Free air in cu.ft. per min.} = \frac{\text{water in gal. per min.} \times \text{lift}}{195 \times \log_{10}\left(\frac{S}{34} + 1\right)}$$

In an actual compressor the compression is not isothermal, and the indicated work done on the air is therefore somewhat greater than $P_a V_a \log_e \frac{P_1}{P_a}$. Because of this the constant 195 is usually taken in round figures as 200, and the formula is then in a form suitable for the draftsman's use:

$$\text{Free air in cu.ft. per min.} = \frac{\text{water in gal. per min.} \times \text{lift in ft.}}{200 \times \log_{10}\left(\frac{\text{submergence in ft.}}{34} + 1\right)}$$

This expression has proved very suitable in obtaining the capacities of compressors for air lifts and is admittedly a great improvement on the older formula.

There is still room for further experimental research upon the air-lift pump and many firms work almost entirely in the dark. It is in the hope of assisting such that the writer has devised the foregoing formula—"Mechanical World."

ENGINEERING AFFAIRS

Brooklyn Association No. 8, N. A. S. E., of Brooklyn, N. Y., at its last meeting was addressed by A. C. Lippincott, New York sales manager of the Keeler Boiler Co., who gave an interesting lecture on boilers, using a glass model demonstrating the circulation in a Keeler boiler.

The Louisiana Engineering Society at its regular meeting Apr. 10, in New Orleans, was addressed by Prof. Charles S. Williamson, Jr., of Tulane University, on "Industrial Resources of Louisiana," and a resolution was adopted indorsing the uniform Boiler Code of the American Society of Mechanical Engineers.

The National Gas Engine Association has hit upon a very creditable plan for serving its members, through the creation of an exchange department. This is intended to meet the present difficulties in obtaining materials by having the members use this department as a sort of clearing house to advise one another of surplus stocks on hand. That is, assume that Smith & Co. have an over-stock of crankshafts than Brown Bros. could use to advantage, while Brown Bros. have a dead stock of cold-rolled shafting that is the very thing Smith & Co. have been trying to get delivery on. By use of the exchange department both will be enabled to clean up their dead stock, both get materials they are in great need of, and a customer's order is filled on time.

Massasoit Association, No. 2, of the N. A. S. E., of Springfield, Mass., held its fourteenth annual banquet at the Highland Hotel on Saturday evening, Apr. 15. There were about 150 present. Theodore N. Kelsey, past national president, was the toastmaster. Seated at the head table were Mayor Frank E. Stacy; Charles W. Winslow, secretary of the board of trade convention committee; National President Walter H. Damon, Past National Presidents William J. Reynolds, Herbert E. Stone and Royal D. Tomlinson, who made addresses in the order named. The other speakers included John F. Quinn, of Holyoke, James Henderson of Boston and Ernest R. Stevens of Somerville. The entertainment comprised numbers by David Oeol, John Brinson, Herbert Self, of the Peerless Rubber Manufacturing Co. and Jack Armour, of "Power." The committee was E. J. Auger, H. D. Newton, A. G. Thompson and W. D. Packard.

The Providence Engineering Society will hold its first annual dinner at the Narragansett Hotel, Wednesday, May 3. This dinner is intended to promote both the social and professional interests of all engineers in Rhode Island and vicinity. Frank B. Gibreth will be toastmaster and the speakers: Mayor Joseph H. Gainer, of Providence; President W. H. P. Faunce, of Brown University; Calvin W. Rice, secretary of the American Society of Mechanical Engineers; David B. Rushmore, engineer, General Electric Co., Schenectady, N. Y., representing the American Institute of Electrical Engineers; a speaker not yet chosen to represent the American Society of Civil Engineers, and Henry A. Wise Wood, president of the Wood Newspaper Machinery Corporation and president of the American Society of Aëronautic Engineers, who will give an address on the subject, "The Wisdom and Ethics of Preparedness."

PERSONALS

H. O. Swoboda has been retained by the Borough of New Brighton, Penn., as consulting engineer for the purpose of planning a new street-lighting system.

C. A. Call who has for the past five years handled the advertising of the G-E Flow Meter has been appointed manager of Publicity for the Terry Steam Turbine Co., Hartford, Conn.

James Clark, Jr., president of the James Clark, Jr., Electric Co., manufacturing electrical equipment and tools, is now a Kentucky colonel on the official list, having been appointed to the staff of Governor Stanley.

O. G. Smith, formerly with the Platt Iron Works Co., of Dayton, Ohio, has been appointed district manager for the National Transit Pump and Machine Co., in charge of its new branch offices in the Marquette Building, Chicago, Ill.

George W. Martin and Jay Grant DeRemer have organized an engineering firm with offices at 100 Broadway, New York, for general practice in public utilities and industrial plants. The new company will also specialize in district heating work.

J. D. Cudney, who for some time has been associated with the Alberger Gas Engine Co. and its subsidiary companies, the Alberger Heater Co. and Howard Iron Works, as sales manager, has recently left their employ and accepted the position of sales manager of the Rathbun-Jones Engineering Co., Toledo, Ohio, builders of the well-known Rathbun gas engine.

NEW PUBLICATIONS

MECHANICAL ENGINEERS POCKET BOOK, Ninth Edition. By William Kent. Published by John Wiley & Sons, New York, 1916. Size, 4x6¾ in.; 1,526 pages. Price $5, net.

This is the ninth edition of a book that needs no introduction to mechanical engineers. The rapid advance in engineering practice and standards during the past few years, or since the eighth edition was published in 1910, has rendered necessary the revision and condensing of nearly one-third the text and the addition of about 150 pages of new matter. Among the subjects thus affected are machine-shop practice, air, heating and ventilation, flow of water, pumps, coal, steam, boiler economy, steam turbines, cooling towers, refrigeration, electrical engineering, illumination, materials and mechanics. The new A. S. M. E. Boiler Code and the recently revised A. S. M. E. committee report on power tests are included. A large number of useful tables have been added, and a much needed improvement in the index has been made by enlarging it to over 5,000 titles.

HANDBOOK OF CARBURETION. By Arthur B. Browne, consulting engineer. Published by John Wiley & Sons, New York City, 1916. Cloth, 6x9 in.; 137 pages; 47 illustrations. Price, $2.

While this book is written for the automobile engineer it should prove useful to anyone interested in the automatic regulation of gas-air ratio in the gasoline engine. In the first chapter a relation is established between air and fuel velocities for eight general types of carbureting apparatus. Unfortunately these types are described only by their titles. The second chapter contains a discussion of intake manifolds with illustrations of good and bad designs.

The next three chapters, comprising one-third the book, give detailed directions for testing carburetors. These directions apply mostly to road tests of the complete car, although the direct determination of carburetor action by measuring the flow of air through an orifice in a thin plate or through a venturi meter is also explained.

The author then outlines the chemical and thermal changes that occur in the cylinder and gives some interesting data on the effect of variation of air-gas ratio on power and thermal efficiency. He also considers the effect on carburetion of such physical conditions as temperature, barometric changes and heat properties of gasoline.

The final chapter presents the author's conception of the salient features of the carburetor of the future, the most important of these being that the principles employed will permit the device to operate satisfactorily with varying fuel compositions and that the mixture of air and gas will have a constant relation.

VALVES AND VALVE GEARS, Volume II: Gasoline, Gas and Oil Engines. By Franklin DeRonde Furman, professor of mechanism and machine design, Stevens Institute of Technology. Published by John Wiley & Sons, New York City. Cloth; 6x9 in.; 190 pages; 170 illustrations. Price, $2.

The first volume of this work relates to valve gears for steam engines and turbines and has previously been reviewed in "Power." The present book is a carefully prepared outline of the operation and construction of internal-combustion engines, although it would seem that the valve mechanisms themselves are given a back seat.

An idea of the ground covered may be gained from the section headings, which are: General Characteristics of Internal-Combustion Engines; Commercial Applications of Various Forms of Valves and Valve Gears to Gasoline Engines; Aëroplane Engines; The Gas Engine; Oil Engines; Diesel Oil Engines.

The opening section gives an elementary survey of the subject describing two- and four-stroke-cycle principles of operation, devices used to prepare the fuel for ignition, igni-

tion methods, and concluding with suggestions for adjusting valves and for laying out cams.

The next section contains directions for laying out valve gears of piston- and cylindrical-valve gasoline engines, and of automobile engines of the Franklin air-cooled, the Cadillac eight-cylinder V-type (the last two with poppet valves) and the Knight double-sleeve-valve engine.

The aëroplane engines mentioned include the Curtiss V-type, the Salmson fixed-radial, and the Gnome and Gyro revolving-radial types. The valve mechanisms used with these engines are described exhaustively.

The section on gas engines contains a brief account of the Lenoir, Otto-Langen, Brayton, Otto and Clerk engines, all of which were developed between 1860 and 1880. The structural details of the gears and valves of the Allis-Chalmers and Westinghouse gas engines are illustrated and their operation explained. In this section the general methods of speed control of gas engines are clearly discussed.

The book concludes with descriptions of the Metz & Weiss, De La Vergne, Bolinder and Diesel oil engines, consideration being given to their general action and construction rather than to the valve mechanisms.

Volume I of this work, "Valves and Valve Gears," was reviewed in "Power," Aug. 24, 1915, page 283.

Recent Court Decisions

Digested by A. L. H. STREET

Pollution of Water-Supply—Where land was leased for coal-mining purposes with such rights in the lessee to use the surface as should be reasonably necessary in carrying on the mining operations, the lessors had no right to so operate a sawmill on the land as to pollute an adjacent stream from which the lessee obtained its supply of water for use in its boilers, by discharging sawdust into the stream. (Kentucky Court of Appeals, Blue Grass Coal Corporation vs. Combs, 182 "Southwestern Reporter," 207.)

Annulment of a Twenty-Five Year Franchise of the Tacoma Railway and Power Co. has been upheld by the United States Circuit Court of Appeals in a decision affirming the holding of the Federal District Court. The case was appealed by the Old Colony Trust Co., of Massachusetts, trustee for the bondholders. The Federal courts sustained the decisions of the state courts in revoking the franchise because the company violated an agreement not to sell electricity for lighting. The City of Tacoma, Wash., gave a permit for limited lighting service in 1908, which it revoked in 1913, following the completion of the municipal lighting plant. Upon the company's refusal to discontinue the lighting service the franchise was annulled.

The Washington State Public Service Commission is without power to compel disclosures by public-service corporations of their contracts, holds the State Supreme Court in denying the writ of mandate sought to compel the Spokane & Inland Empire Railway Co. to disclose the nature of a private power contract it had with the Washington Water Power Co. The public-service commission sought the writ on the ground that it had to know the nature of the private contract as a basis for rate making. "The state has no interest in appellant's gains or losses in its private enterprises," says the court in its ruling. "To hold that the commission could figure the appellant's private contracts as a basis for rate making would in turn compel the holding that appellant would be entitled to take from the public enough to make good its losses in its private enterprises." The question involved in the decision was whether the 1911 public-service law could be extended so as to allow the public-service commission jurisdiction over power companies regardless of the business carried on. The ruling of the court that private contracts of such companies are immune from investigation is an important one, being the first adjudication of this question.

MISCELLANEOUS NEWS

Lexington, Ky., is Considering an Anti-Smoke Ordinance drafted on the lines of the Des Moines measure by Mayor Rogers.

The Smoke Abatement League of Louisville, Frank N. Hartwell, of H. Verhoeff & Co., president, is promoting a movement to enact an effective smoke-prevention ordinance in Louisville, Ky.

The Russian Ministry of Finance is offering prizes for new methods of using alcohol in place of gasoline and for substances that will serve for the denaturization of the spirit. The competition will remain open until Sept. 1 and the adjudging of the prizes until Mar. 1, 1917.

City Plant to Buy Electricity—Mayor Gill, of Seattle, believes that the city may practice economy in its search for additional light and power by calling for bids to supply 22,000 kw. of electric energy to the municipal plant, the city council reserving the right to purchase the plant of the successful bidder.

The Number of Pumping Plants for irrigating land in three Southern states, according to W. B. Gregory in a paper at the spring meeting of the A. S. M. E. at New Orleans, is as follows: Arkansas, 315 plants using 12,440 hp.; Louisiana, 1,007 plants of 57,426-hp. capacity; Texas, 575 plants having 48,179 hp.; in all, 1,897 plants aggregating 118,045 hp.

Boiler Code Valves—The following manufacturers have advised that they are prepared to supply valves built to meet the requirements of the A. S. M. E. Boiler Code. American Steam Gage and Valve Manufacturing Co., Boston; The Ashton Valve Co., Boston; The Consolidated Safety Valve Co., New York; Crane Co., Chicago; Crosby Steam Gage & Valve Co., Boston; The Lunkenheimer Co., Cincinnati.

Washington Water-Power Survey—The survey of the water powers of the Cascade Range in Washington will be completed within the present year, and the state geological survey will then be ready to furnish information in detail of the 5,000,000 hp. in the streams of the Cascades. The water-power survey was started in 1909 and will be finished with the mapping of the river profiles of the Nooksack River and all its branches.

Municipal Lighting Plant Raises Rates—The City of Ellensburg, Wash., after several years' operation of its municipal lighting and power plant finds that a great many outstanding lighting-department warrants have not been paid for over three years and cannot be paid unless additional funds are forthcoming. To meet the emergency the lighting rates have been advanced on a sliding scale on an average for residence and business lighting of 10 per cent. The minimum rate on residence lighting has been raised to $1 per month. No discounts will be allowed as heretofore on lighting and power bills.

New Wisconsin Boiler Code—The Industrial Commission of Wisconsin has just issued the new Wisconsin boiler code to govern all steam boilers except those regularly inspected by the Federal Government, steam fire engines, those used exclusively for agricultural purposes, all of less than 10 hp., and those on which pressure does not exceed 15 lb. per sq.in. The code was recommended by a special committee consisting of Theodore O. Vilter, Milwaukee; H. F. Bowie, inspector, Hartford Steam Boiler Inspection and Insurance Co.; W. D. Johnson, secretary, Milwaukee Boiler Co., Milwaukee; R. Kunz, chief examiner, Milwaukee Board of Stationary Engineers Examiners, and H. E. Pressinger, deputy Industrial Commission of Wisconsin.

Philadelphia Rate Case Compromised—The case of the City of Philadelphia vs. the Philadelphia Electric Co. before the State Utilities Commission of Pennsylvania has been settled by an agreement between the city and the company, whereby a reduction of $1,250,000 per year is to be applied by the State Utilities Commission to the electric rates, reducing the rates for residence and commercial lighting to an amount that will represent a reduction in revenue, as stated. This settlement gives the city three-quarters of what it contended for and came about by way of a proposition from the electric company to compromise the case without waiting for a decision from the commission. This is a decided victory for Morris Llewellyn Cooke, under whose administration, as Director of Public Works, the application was filed, and for F. W. Ballard, under whose administration the municipal station at Cleveland was successfully inaugurated, and who was active in preparing the city's side of the case cited.

The Purchase of Coal by the Government under stringent contracts that specify the heating value, the ash and the moisture content, and other factors, first used in 1906, has now been adopted by all departments of the Government, and is applied to almost all contracts. The aggregate cost of fuel so purchased is approximately $4,800,000 per annum. During the last fiscal year, 7,527 samples of coal were analyzed by the Bureau of Mines to ascertain whether the deliveries conform to the contract stipulations. In each contract a bidder guarantees the quality of the coal he offers, and the quality so guaranteed becomes the standard of his contract. If the coal delivered is not up to the standard, the price paid is proportionately decreased; if it is of higher quality, the price is proportionately increased. Some of the states, larger cities and a large number of corporations have followed the Government's plan for the purchase of coal.